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GEOLOGY

OF THE

BOWEN RIVER COALFIELD.

By

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PREFACE.

This report by Mr. Reid represents an important contribution to the Permo-Carboniferous stratigraphy of the State, a phase of geology that has a particular economic significance in so far as the formations of this system contain, to an overwhelming degree, the bulk of the future coal resources of Queensland. This work was carried out during 1924, but was preceded by a considerable amount of fieldwork around the Collinsville area, during the period 1912 to 1916, by myself, with the assistance of the late L. R. Blake, M.C., and R. Graff of the Geological Survey staff. After directing the preliminary prospecting operations in 1912 on the Garrick Seam, my own investigations were, later, intensified nearer to the present State Mine area, and resulted in the opening there of the important Bowen Seam. My annual report for 1914 indicated the following conclusions regarding the geological work carried out at that period:—

> "Progress has been made with the work of prospecting the coal seams of the Bowen Coalfield since the last annual report was furnished, the fieldwork since then being undertaken by Mr. L. R. Blake.
>
> "The geological mapping has shown that the measures are well defined, and rest conformably on a series of beds which apparently do not contain coal, and which might be the equivalents of the Permo-Carboniferous Lower Marine Series. The geological examination also shows that the measures are overlaid by a great thickness of fossiliferous sandstones, &c., belonging to the Upper Marine Series of the same system.
>
> "The Lower Series consists of conglomerates and agglomerates, both made up of volcanic material; but further examination will be necessary before anything definite is stated regarding its other stratigraphical features. No marine fossils have been found, but amongst the conglomerates the fern *Glossopteris* has been noticed, while near the top there is a gradual emergence into coal-measure conditions.
>
> "The coal measures above the Lower Series contain four coal seams, the smallest varying in thickness from 2 to 6 ft., the largest varying from 20 to 29 ft."

The drilling results following the preliminary geological survey work were indicated in the following extract from my Annual Report for 1916:—

> "No. 1 State Mining Area on the eastern portion of the field has been prospected by a series of bores to prove both deep and shallow ground, and the results have been so satisfactory that no hesitation has been felt in strongly recommending that the building of the line be taken in hand.
>
> "The results of the boring operations on No. 1 State Area show that seven seams of coal have been proved by the seven bores already sunk, and in an area of 1¼ square miles there is a thickness of about 40 ft. of coal. The Bowen Seam, the most important in the area, will probably be found to contain very large quantities of available coal, as the seam has a minimum thickness of about 13 ft., the upper 7 ft. 6 in. of which contains an ash percentage of not more than 13 per cent."

Mr. Reid has continued the geological work thus initiated some years earlier, and after a considerable amount of detailed work in the environs of Collinsville, which, incidentally, established the existence of a very valuable index bed (the "big" Strophalosia horizon) for the future extension of the coal seams, he extended the examination as a reconnaissance survey to the remainder of the coal basin within the Bowen River watershed. This work has demonstrated the southern extension of the Middle Bowen Series, including the coal measures, towards the Isaacs River basin.

B. DUNSTAN,
Chief Government Geologist.

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GEOLOGY OF THE BOWEN RIVER COALFIELD.

INTRODUCTION.

It is forty-nine years since the Bowen River coalfield was reported on by Dr. R. L. Jack.* Since that time the coal seams with their vast tonnage of unworked coal have remained practically untouched until the last few years. The field has recently become of commercial importance for, with the linking up of it to the town of Bowen by a railway, two collieries—the State Colliery and the Bowen Consolidated Colliery—are in active operation, and the output has become important and is increasing. The output of the State Colliery at Collinsville exceeds that of any other individual colliery in Queensland at present.

The present work was carried out primarily with the view of linking up and correlating the geological formations of the field with those of the continuation of the Dawson River and Mackenzie River Coal Basins further south, mapped by Cameron† in the vicinity of Nebo and Mount Britton; also with the further view of obtaining some information about that great expanse of practically unknown coal-bearing country lying to the south of the Collinsville area, in which latter locality the seams have been examined and mapped in detail in recent years and the coal measures tested by means of numerous bores. This southern area comprises Blenheim, the plains of Havilah, Byerwin, &c., extending to the Leichhardt Range, where scarcely any previous geological work has been carried out south of the area mapped by Jack. The field is so large and much of it is so far from any centre of population that it would require a geological staff with established camps to map in detail the greater portion of it. Geological work is hampered, too, by extensive areas of brigalow scrub.

The present report is therefore mainly based on reconnaisance mapping between Eungella (west of Mackay), the Leichhardt Range towards Mount Coolon, Strathmore Station on the Bowen River, and the Clarke Range at the northern end of the field. The distance is 70 miles in a N.W.-S.E. direction between Mount Hillalong Station and Table Top Mountain, and as the average width of the basin mapped would be about 24 miles, the total area mapped is thus approximately 1,700 square miles. In addition, many detailed examinations and sections were made at favourable points, as well as a considerable amount of detailed mapping carried out around Collinsville where the State Colliery is situated. By combining the data derived from both classes of work, the sequence, thickness, character, and geographical distribution of the different sedimentary series of

* R. L. Jack. The Bowen River Coalfield. Q.G.S. Pub. 4. Brisbane. 1879.

† W. E. Cameron. The Central Queensland Coal Measures. Q.G.S. Pub. 200. 1905.

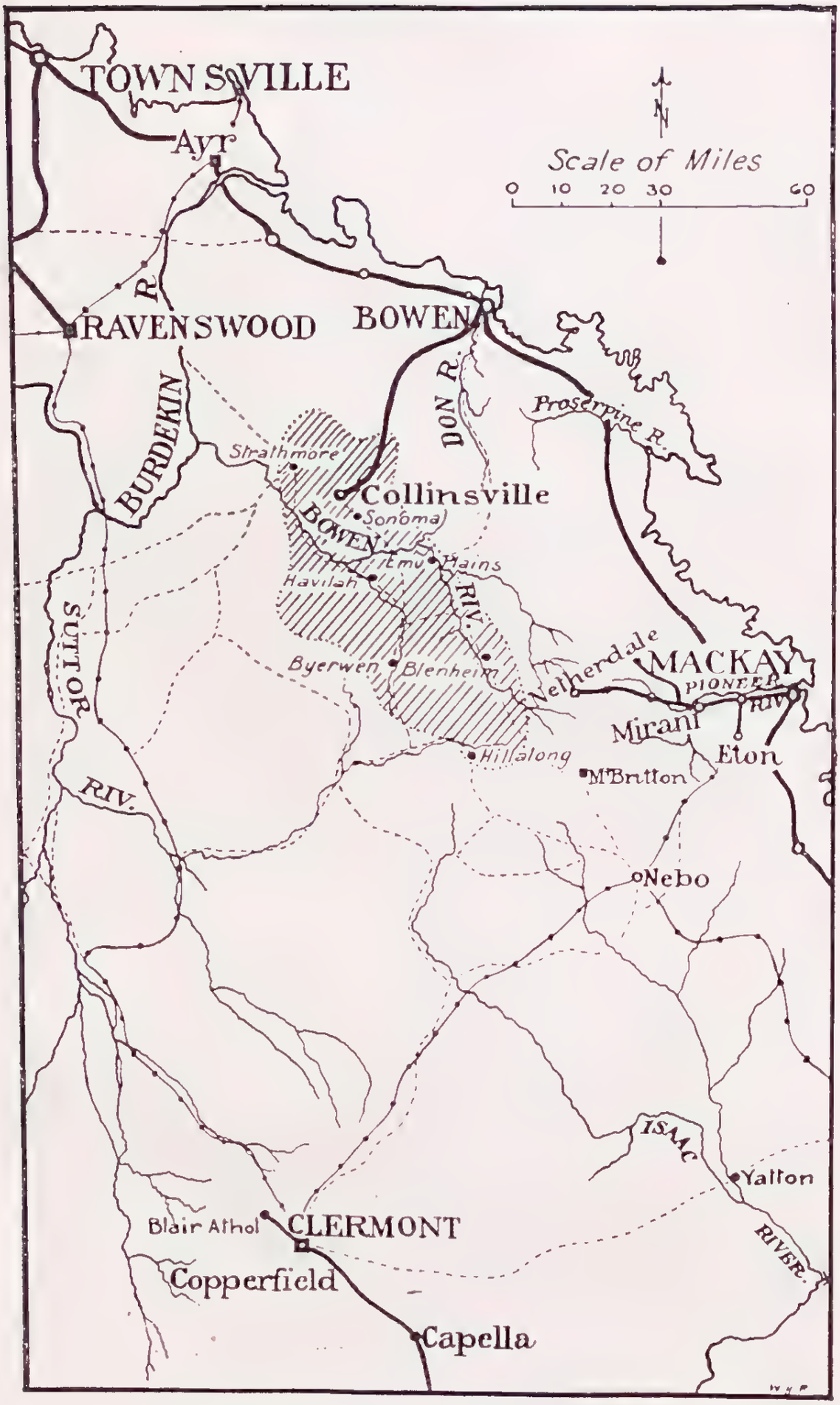


Fig. 1.—Locality Map of Bowen River Coalfield.
(Area mapped shown by shading.)

the coal field have been defined with reasonable accuracy, particularly as to the Marine Series and the Collinsville Coal Measures. To the Marine Series particular attention has been devoted on account of its importance for correlation with marine series in other coal fields of Permo-Carboniferous age in Australia, and owing to the fine natural exposures of its members and its many magnificent fossil horizons it now stands revealed in fairly complete detail. As to the Middle (or Collinsville) Coal Measures the detail of these has been largely elucidated by the unpublished detailed map of Blake and Graff, prepared under the direction of the Chief Government Geologist, Mr. B. Dunstan, of the country between Collinsville and Pelican Creek, some 9 miles to the south-west of the State Colliery, supplemented by a large number of diamond drill bore records in possession of the Queensland Geological Survey. Altogether about twelve weeks were spent in the field on the present geological work. The writer travelled by buckboard over the Eungella Plateau, from Mackay, traversing a particularly difficult road and striking the coal basin in the vicinity of Blenheim Station. The route followed went as far south as Mount Hillalong Station on the Suttor watershed, really to make a detour of the Redcliffe Range whose massive sandstone ramparts stand as an obstacle to east-west roads, through Byerwin on to the Mount Coolon road-crossing of the Leichhardt Range which was the furthest south-westerly point reached. The broad volcanic plains of Strathmore and Birralee Stations, spreading out to the north-west and west of the coal field, were traversed rapidly, as well as the continuation of the same series exposed to the north of Mount Devlin. About four weeks were devoted to detailed mapping around the State Mining area and Consolidated Mine at Collinsville.

In the accompanying map the boundaries, where accurately mapped, are shown in solid lines. The boundary between the Lower Bowen Volcanics and the Lower Palæozoic (?) basement rocks can only be considered very roughly approximate in most cases. As these volcanics extend well in towards the Clarke and adjoining Ranges on the east side of the field, this boundary is placed at times in almost inaccessible positions. The purely sedimentary rocks occurring in the Lower Volcanics have not yet been mapped except around Mount Devlin, and odd occurrences on Strathmore Creek, and beyond these they are probably unimportant with the one exception, perhaps, of those at the Bowen River Crossing, near Strathmore.

Acknowledgment must be made of courtesy and valuable assistance of various kinds received from Messrs. A. J. Hall-Scott, Managing Director, Bowen Consolidated C.M. Co.; A. H. W. Cunningham, of Strathmore; Geo. Ferguson, of Byerwin; W. Richards, of Mount Hillalong; J. Bailey, Manager of Blenheim; J. McNaughton, Manager, Consolidated Mine; and especially James Conway, Manager of the State Colliery, Collinsville, and the office staff there. The assistance rendered included the loan of blackboy guides, horses, and sometimes provisions.

GENERAL DESCRIPTION OF FIELD.

The Bowen River Coalfield lies within latitudes of 20° 20′ S. and 21° 20′ S. and longitudes 147° 30′ E. and 148° 20′ E. It occupies almost the whole of the watershed of the Bowen River above its confluence with Pelican Creek. At the northern end of the field the town of Collinsville, which has sprung up around the State Colliery, is connected by railway to the port of Bowen, the distance being 53 miles. Apart from this town, and the township of Scottsville that has grown up around the Bowen Consolidated Mine, there is no other community settlement on the field. Communication is by a few roads only, and these routes have almost all been pre-determined by the topography of the region. The principal roads are Collinsville to Mount Coolon Goldfield, *viâ* Havilah Homestead; Collinsville to Mackay, *viâ* Emu Plains and Blenheim Homesteads, with a branch road running south through Mount Hillalong Homestead to Nebo; a coach route from Collinsville to Birallee, Strathmore, and Strathbowen.

The coal field occupies a low-lying basin, varying from 400 ft. to 1,000 ft. above sea-level, fringed by ranges. On the north and east the Clarke Range rises to altitudes of 2,000 ft. to 3,000 ft. above sea-level; on the south and south-west the low divides of the Denham (1,700 ft.-1,800 ft.) and Leichhardt (1,400 ft.-1,600 ft.) Ranges separate the field from the Suttor River watershed. On the north-west the Bowen River makes its escape by a wide gap through the enclosing ranges.

The greater portion of the coal field occupies the rather mature valley of the Upper Bowen River. Viewed from a number of surrounding hills most of it looks to be almost a dead-level plain. This flatness particularly applies to the area north of the Bowen River, near Havilah. The southern portion is much more undulating to hilly.

The Redcliffe Tableland, consisting of massive and nearly horizontal sandstones, rises rather centrally in the southern portion of the field to a height of about 2,200 ft. to 2,300 ft. above the sea. The trend of it is north-west to south-east, its length is 26 miles and its greatest breadth about 6 miles. Mount Leslie is an outlier of the same geological formation. The tableland presents mural walls of buff-coloured to red sandstone on both eastern and western sides, which are up to several hundred feet in height and effectively bar east-west roads for its entire length. The country to the west of Redcliffe Tableland is undulating to hilly, most of the hills consisting of basaltic pinnacles which are numerous between Byerwin Homestead and Cockatoo Creek.

The water supply on the field is uncertain in many localities. The Bowen River appears to have perennially flowing water below its junction with the Broken River and more or less

permanent waterholes as far south as Blenheim. Hazelwood Creek contains good waterholes in its lower course. Rosella Creek is said to carry permanent waterholes. The south-western portion of the field appears to carry no surface water over dry periods and cattle are watered from bores on Cockatoo and Plum Creeks. The water supply in Pelican Creek is precarious, and during 1923 the needs of Collinsville were with difficulty obtained by pumping from the gravels in the bed of the creek. Collinsville is about 13 miles from the nearest point of the Bowen River, and an increase in population must make imperative the securing of water supplies from that river—a project which is already under consideration.

The soils over the greater portion of the coal field are extremely fertile. The Lower Bowen Formation, largely composed of basic volcanics, gives rise to the rich blacksoil plains of Strathmore, Birallee, and elsewhere. The Collinsville Coal Measures produce rather heavy sands and sterile soils

Fig. 2.—Main Street, Collinsville, in 1924. [*Photo., J. H. Reid.*

which support stunted gum and box as well as rosewood, budda (*Eremophila Mitchelli*) and "Quinine" (*Petalostigma quadriloculare*). The two latter species were identified by Mr. C. T. White, F.L.S., Government Botanist. The Middle Bowen Marine Series usually produces open undulating forest country marked by light red sandy soils. The greater portion of the field is occupied by rocks of the Upper Bowen Series of tuffaceous sandstones, shales, tuffs, &c., with many small intrusions of dolerite, &c. The soils generally are very fertile, the blacksoil plains of Havilah, Byerwin, &c., being noted for their richness. These consist of friable, loamy, and calcareous soils and support extensive scrub areas of brigalow. To a slight degree light red sandy soils occur also on this formation. On these brigalow and budda flourish. Suitable mining timbers are abundant on most portions of the coal field.

PREVIOUS LITERATURE.

1872. Daintree, R.—Geology of Queensland. Quar. Jour. Geol. Soc. London xxviii.

1872. Etheridge, R.—Queensland Fossils. Appendix I. to Geol. of Queensland, by R. Daintree.

1879. Jack, R. L.—The Bowen River Coalfield. Queensland Geol. Survey Publication No. 4, with Geological Map.

1880. Etheridge, junr., R.—On a collection of fossils from the Bowen River Coalfield, &c. Proc. Roy. Phys. Soc. Edin., vol. v., pp. 263-328.

1890. Maitland, A. Gibb.—In Annual Progress Report of the Queensland Geological Survey for 1889. Q. Geol. Sur. Pub. No. 58.

1892. Jack, R. L. and Etheridge, junr., R.—Geology and Pal. of Queensland, pp. 143 *et seq.* Q.G.S. Pub. No. 92.

1912-1917. Dunstan, B.—Office Memoranda on Prospecting and Development of Coal Areas. Q. Govt. Min. Jour. 1912, p. 485; 1913, p. 648; 1915, p. 360; 1917, p. 375.

As Daintree's report embraces the wide field of Queensland Geology only general references to the Bowen field are made. The statement (p. 286) that "the whole of these forms (*i.e., marine fossils*) agree with those found in New South Wales, which there, as in Queensland, are found at the base of the great Palæozoic coal-group of that Colony" is not correct for the Bowen River Coalfield only, since so far there is no record of marine fossils having been found on an horizon below the productive coal measures now being worked at Collinsville.

Daintree also refers to *Streptorhyncus crenistria* (= *Derbyia senilis*) being so common throughout all the Lower Marine Series. *Strophalosia Clarkei* is the dominant species numerically on the field and has a wide range, and there are many others which appear much more plentiful than the one cited by Daintree. Jack only records it in four localities in the Marine Series of the Middle Bowen, and the present writer has only found it in the one small horizon therein.

Dr. Jack's report (1879) is the only comprehensive report on the coal field to date. A geological map accompanied the report showing broadly the boundaries of the Bowen formations according to his classification. Many detailed sections are given in the text of his report as well as a lengthy list of the fossils occurring throughout the coal field. Jack's classification remains practically unaltered, but as much additional information has since been collected it has become expedient to revise it slightly. His correlation of the Bowen Series with the New South Wales Permo-Carboniferous System is also partly supported. These facts are a tribute to the work of Jack in what

was then practically an unknown district geologically, and with the most meagre map on which to base his geological work. His report has been of the greatest value in preparing the present one. A. Gibb Maitland followed Jack's classification and mapped in broadly the country south of the area examined by Jack. Maitland shows that the Bowen Marine Series continues unbroken to the south-east as far as Nebo Creek, about 70 miles from where Jack ceased his examination.

The reports of Mr. B. Dunstan, Chief Government Geologist, from 1912 to 1917 expose the progress of the field from the inception of prospecting to actual coal-mining operations. In 1912 Mr. Dunstan examined portion of the field, particularly with reference to the outcrops of the Garrick and Daintree seams mentioned in R. L. Jack's reports. He recommended a subsidy for prospecting the Garrick Seam on the banks of the Pelican Creek, and a 4 ft. 6 in. seam of good quality was afterwards proved there. Following this, coal outcrops were discovered near Mount Devlin, and these discoveries proved the prelude to prospecting and, subsequently, mining operations in the State Mine area. On examination of these outcrops and the seams disclosed in prospecting shafts, Mr. Dunstan, in 1913, expressed the opinion that an immense area of coal existed there, and recommended a diamond-drilling campaign. This was accomplished in 1914 and subsequent years, and was accompanied by detailed geological mapping carried out under the Chief Government Geologist's direction by Messrs. (the late) L. R. Blake, M.C., and Graff. In 1914 Mr. Dunstan announced that the coal series was underlaid by a series of conglomerates and agglomerates, which he thought might be equivalent to the Permo-Carboniferous Lower Marine Series, and overlaid by a great thickness of fossiliferous sandstones belonging to the Upper Marine Series. In 1916 it was stated that the results of the drilling in No. 1 State Area showed seven seams present, and in an area of 1¼ square miles a total thickness of about 40 ft. of coal was proved. As a result of this work Mr. Dunstan recommended construction of a railway from Bowen to the field, and this was started during the year 1916.

The following reports refer to areas in surrounding districts where Permo-Carboniferous rocks have been described, and these have been drawn on for references in the correlation of the Bowen Coalfield formations:—

Rands, W. H.—Geology, &c., of Clermont. Q.G.S. Publication 27. 1886.

Jack, R. L.—Geol. Features of Mackay District. Q.G.S. Pub. 39. 1887.

Maitland, A. G.—Geol. Features of Mackay District. Q.G.S. Pub. 53. 1889.

Jack, R. L.—Annual Progress Report Geological Survey for 1894 (on Springsure and Clermont, *see* pp. 9, &c.). Q.G.S. Pub. 103.

Dunstan, B.—Geology of Collaroy and Carmilla, &c. Q.G.S. Pub. 141. 1898.

Permo-Carboniferous Coal Measures of Clermont. Q.G.S. Pub. 148. 1900.

Geology of Dawson and Mackenzie Rivers, &c. Q.G.S. Pub. 155. 1901.

Geological Features of Hazledean. Q.G.S. Pub. 164. 1901.

Cameron, W. E.—Additions to Geology of Mackay and Bowen. Q.G.S. Pub. 181. 1902.

Central Queensland Coal Measures. Q.G.S. Pub. 200. 1905.

Reid, J. H.—Permo-Carboniferous Geology of Queensland—Additional Notes. "Queensland Government Mining Journal," February, 1924.

[*Photos., J. Conway.*

Fig. 3.—Two Views of the State Colliery, Collinsville.

COAL RESOURCES.

THE LOWER BOWEN COAL MEASURES.

Interbedded with the volcanic rocks of the Lower Bowen Formation are sandstones and conglomerates in which coal occurs at the north-eastern base of Mount Devlin. These are now referred to as the Lower, or Mount Devlin, Coal Measures, and are about 400 ft. thick. On the evidence so far established they are not likely to be productive. The discovery of coal here was incidental to railway construction work, and a shaft 53 ft. deep was put down by Mr. James Conway, Manager of the State Colliery, to prospect for the seam. At 46 ft. the first coal was struck, and the following section was supplied to me by Mr. Conway:—

Sandstone roof	—	
Splinty *coal*	2ft.	(46 ft.)
White clay	10 in.	
Coal (inferior)	1 ft.	
White stone	1 ft.	
Coal (inferior)	10 in.	(51 ft. 8 in.)
	5 ft. 8 in.	

The location of the coal shaft is about 15 chains north of the 45-mile peg on the railway line. The Mount Devlin Coal Measures have been traced for about 7 miles around the east, north, and west of Mount Devlin.

Sedimentary rocks have been found occurring interbedded with the Lower Volcanics at various points on Strathmore and Birallee Stations, the greatest development being at the Bowen River Crossing, about 4 miles south-west of Strathmore Head Station. *Glossopteris* was found there *in situ*. These beds are probably a continuation of the Mount Devlin Measures. The discovery of further seams in the sedimentary rocks associated with the volcanics must be considered as quite a possibility of the future.

THE MIDDLE BOWEN COAL MEASURES.

These are considered to be the equivalents of the Greta Coal Measures in the Hunter River District, New South Wales, and are referred to as the Middle Bowen or Collinsville Coal Measures. They contain the most important seams known up to the present on the field, and from two of them—the Bowen and the Garrick—the output of the field is at present entirely produced. The measures have been proved to outcrop on both sides of the synclinal basin, from the northern margin of the field to a few miles south of the Bowen River, so that they can be safely assumed to underlie the northern portion of the field

occupying an area of about 400 square miles, and attaining a maximum depth of possibly 6,000 ft. in this area on the axis of the syncline. They may underlie the entire coalfield—an area of about 1,700 square miles.

The more important seams (*see Fig.* 25), in descending order, are:—

(6) Garrick	(3) Potts
(5) Scott	(2) Bowen
(4) Denison	(1) Blake

In addition to the above list boring has proved the occurrence of smaller, and usually lenticular, seams some of which are shown in the plate in this report depicting the correlation of the seams in the bores. It is only in the north-western corner of the field, that is between Collinsville and Pelican Creek below its junction with Three-mile Creek, that the seams have been both mapped at the surface and proved underground by boring. The known

Fig. 4.—Outcrop of Bowen Seam, 20 Chains N.W. of Northern Corner of M.L. 46; 12 Feet of Coal Exposed.

coal-bearing area, more or less proved to a depth of up to 800 ft., comprises about 20 square miles. There is every reason to believe the seams continue undiminished as to thickness beyond this area. Twenty chains east of the State Colliery at Collinsville the Coal Measures become extremely folded and faulted, and an extension of workable seams in that direction cannot be predicted. At the other end of the partly proved area, i.e., towards Pelican Creek, the principal seams, in the aggregate, show no tendency to thin, so they can be assumed to continue on further. The coal measures in the drilled area, as well as over the greater portion of the entire coal basin, have been extensively intruded by igneous rocks, mostly in the form of sills, and each seam has

been detrimentally affected, or destroyed to some extent, in portions of the field.

The following general notes on the principal seams within the drilled area of 20 square miles have been compiled from the records of the diamond drill bores:—

(1) *Blake Seam.**—This attains the greatest thickness of any seam in the field. In No. 24 bore it contains 23 ft. 8 in. of coal (or 30 ft., if the upper portion of the seam separated by 5 ft. of clay shale be included), 12 ft. of which is described as of fair quality, while the remainder is partly coked or destroyed. It is the lowest seam of any note recorded, and has only been reached

Fig. 5.—Adit on Garrick Seam, Pelican Creek, near No. 1 Bore.

by five of the deeper bores. Its continuity through the area drilled is practically certain. In the eastern portion, near Collinsville, it varies from 6 ft. 3 in. to 11 ft. of coal (in No. 18 bore—quality noted as inferior). Towards the west, bores Nos. 24 and 26 have proved it to exist in the No. 2 State Reserve, but it is excessively intruded, and in the latter bore is entirely coked. (*For drill cores, see Fig.* 17.)

(2) *Bowen Seam.*—This averages out as the thickest seam in the drilled area—it is certainly the most valuable on account of its uniform thickness and quality. It is badly intruded in all bores west of No. 5, which thus represents about half of the drilled area and includes the State Coal Reserve No. 2 and the country south-west thereof to at least Pelican Creek. East of

* In memory of the work on this field of the late Capt. L. R Blake, M.C., formerly of the Queensland Geological Survey, killed in action in 1918 in the Great War.

No. 5 bore it is practically free from any effects of intrusions, although in No. 23 bore it was reported by the borer as "partly burned." From No. 29 bore, eastwards, the lower or main portion of the seam averages 14 ft. 3 in. of coal almost free from bands—maximum thickness, 19 ft. 7 in. in No. 30 bore; minimum thickness, 10 ft. 9 in. in No. 19 bore. The upper portion, or Vale Seam, if included, makes a maximum total thickness of 20 ft. 3 in. of coal in No. 23 bore. (*For drill cores, see Fig.* 14.)

No. 26 bore is the most westerly point the Bowen Seam has been proved underground, and the bore record in it suggests that the seam there has split into thin worthless bands of coal separated by sandstone. At No. 1 bore—put down many years ago under the direction of Jack—the estimated depth of the

Fig. 6.—Outcrop of Garrick Seam, Pelican Creek, near No. 1 Bore.

Bowen Seam was attained, but the bore passed through 50 ft. of dolerite and stopped there, and it is apparently the same sill as that (11 ft. thick) found with coal at the Bowen horizon in the No. 26 bore. The Bowen Seam lies from 20 ft. to 74 ft. below the horizon of the Potts Seam.

The Vale Seam is referred to as lying frequently within a few feet of the top of the Bowen Seam.

(3) *Potts Seam.*—This is one of the less important seams, but it will be found to contain useful areas of workable coal. Its thickness is very variable, ranging from two 4 in. bands in No. 24 bore to 9 ft. of coal in No. 17, where the entire thickness is "burned" by an intrusion. In several bores the seam is not recorded. On the whole it is a small seam, and is noted in the bore records as being of "inferior" to occasionally "good" quality. The seam is best in the area in the vicinity of the

State Colliery, where the bores between Nos. 15 to 31, inclusive, show from 2 ft. 10 in. to 8 ft. of coal. In the western half of the drilled area it is very irregular in thickness. The Potts Seam lies from 20 ft. to 52 ft. below the horizon of the Denison Seam.

(4) *Denison Seam.*—This seam preserves a uniformly workable thickness of coal in all the bores. It has, however, suffered much deterioration as the result of intrusions. Its minimum thickness is 3 ft. 6 in. (in Nos. 5 and 24 bores) and maximum 8 ft. (in No. 19 bore). The Nos. 24 and 26 bore records indicate

Fig. 7.—Outcrop of Large Sill amongst Coal Seams N.W. of M.L. 46, near Scottsville.

that probably the greater portion of No. 2 State Coal Reserve is underlain by a workable seam of good-quality coal. No. 25 bore proves that in the northern corner of that area it has been more or less destroyed by intrusion. Between bores Nos. 5 and 4 and between Nos. 13 and 19 workable sections exist, but in the intervening bores it has been affected by intrusions. The Denison Seam lies from 10 ft. to 20 ft. below the horizon of the Scott Seam. (*For drill cores, see Fig.* 15.)

(5) *Scott Seam.*—This seam appears to be a good workable one in the greater portion of No. 2 State Coal Reserve, but like the Denison it is destroyed in No. 25 bore. From No. 25 bore eastwards to No. 18 the records show that it is destroyed totally or badly affected by intrusions. Thence eastwards it is free of these and varies in thickness from 2 ft. to 6 ft. 8 in. of fair to good quality coal with an average thickness of 5 ft. 3 in. The best working areas appear to be in the No. 2 State Coal Reserve and in the vicinity of the State Colliery. The Scott Seam lies

from 200 ft. to 245 ft. below the horizon of the Garrick Seam. (*For drill cores, see Fig.* 15.)

(6) *Garrick Seam.*—This seam ranks so far as the most important economically after the Bowen Seam. On the western portion of the drilled area it is either entirely destroyed by sills or badly split by bands where the bores have penetrated it. From No. 5 bore eastwards it is free from intrusive effects and varies in thickness from 3 ft. 6 in. to 9 ft. 5 in. and averages 7 ft. thick. The coal is usually soft and friable, and on stacking at the surface has a tendency to form slack and to generate spontaneous combustion. The Garrick Seam around Collinsville usually lies about 120 ft. below the horizon of the lowest bed of the Marine Series, but in other localities the interval is not more than 25 ft.

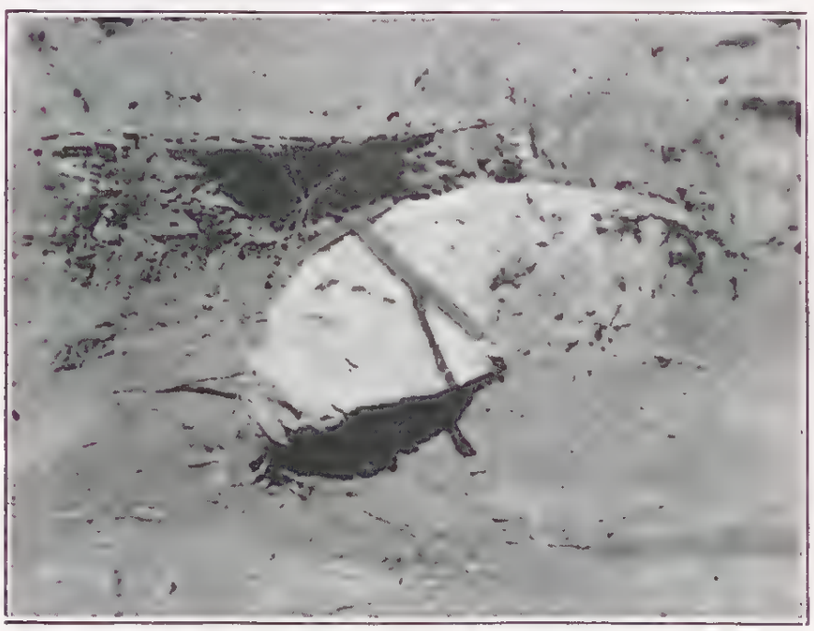
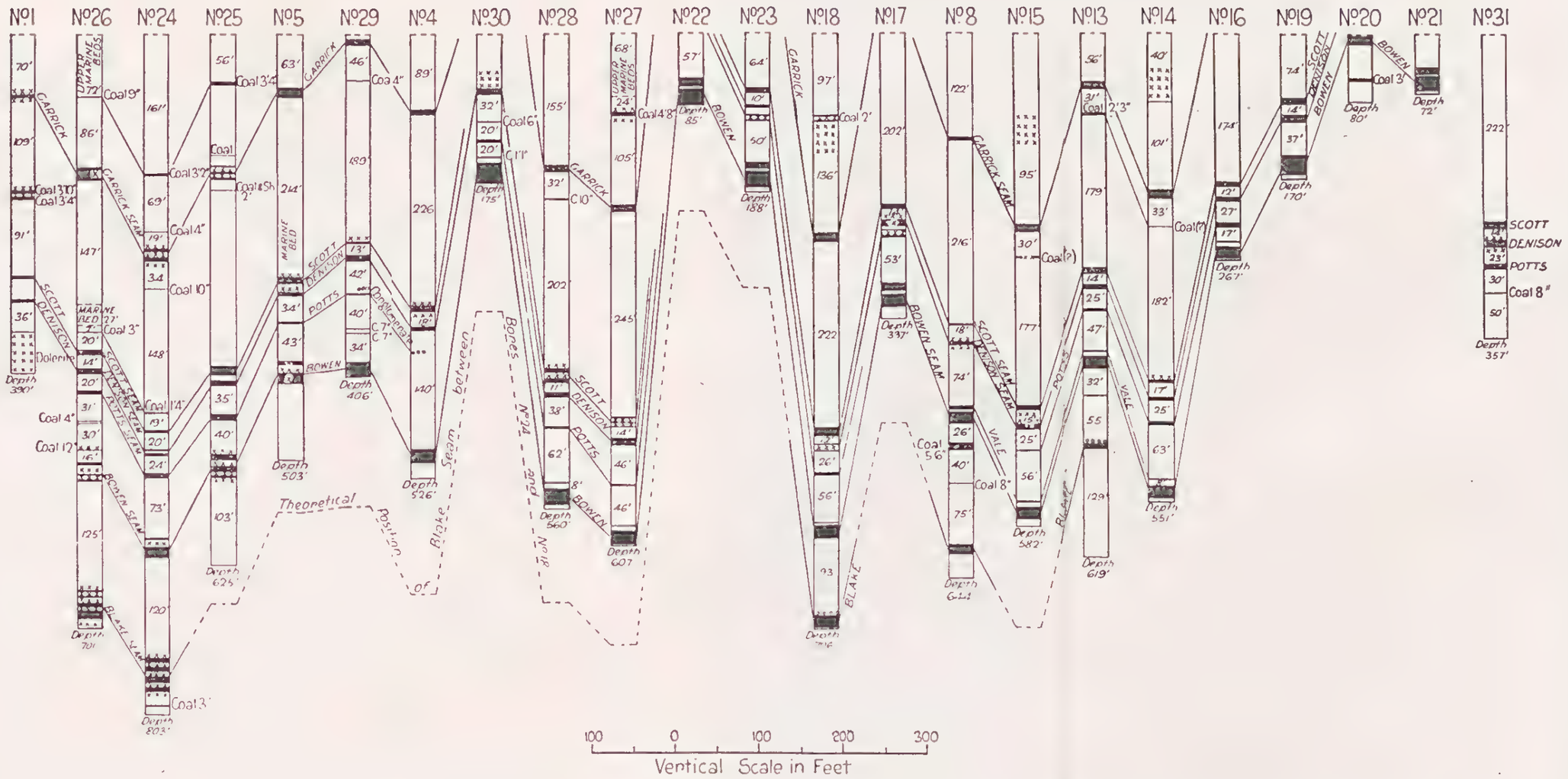


Fig. 8.—Tongue of Decomposed Sill in Outcrop of Blake Seam, East Side, No. 3 State Reserve.

Correlation of Seams.

The accompanying diagram (*Fig.* 9), showing the correlation of the seams, has been prepared from the bore records. The stratigraphic intervals between the main seams are fairly regular, and in the aggregate the interval between the highest and lowest seams is nearly a constant figure for any portion of the drilled area. A useful horizon for correlation is the marine band lying about 30 ft. above the Scott Seam. This is particularly so in the western half of the area where it also outcrops, but in the eastern half it has not been recorded in the bores and has not been observed so far to make an outcrop at the surface. Apart from the marine band there are not many useful indicator beds, and the stratigraphic interval between the seams has been used frequently in compiling the chart from the bore records.



Intrusive Porphyrite affecting seams mostly as sills

Bores omitted Nos 2 & 7 being outside Collinsville Coal Measures

Nos 3, 6, 9, 10, 11 & 12, cannot be correlated satisfactorily and the records of these bores are believed to be incomplete and faulty.

Government Bores. Nos 1, 13 - 26 & 31

Bowen Consolidated Coal Mines Ltd Bores Nos 27 - 30

Brisbane - Bowen Coal Co Bores Nos 3, 9, 10, 11 & 12

Towers - Bowen Coal Co Bore No 4

Bowen River Coal Co Bore No 6

Bowen Coal & Coke Co Bore No 5

W. T. Wharton & Co Bore No 8

N.B. Figures inside bore diagrams shew intervals in feet between seams &c

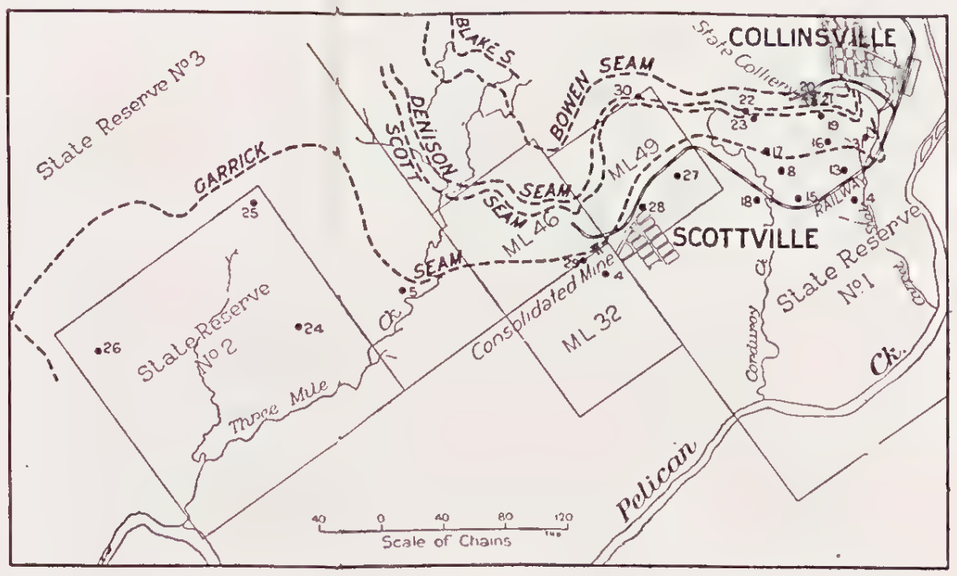


Fig. 9.—Correlation of Coal Seams in Diamond Drill Bores on Bowen River Coalfield, near Collinsville.
Locality Map of Diamond Drill Bores (Lower Right-hand Corner).

Face p. 14.]

Intrusions in Coal at Collinsville.

A general feature of the geology of the coal field is the large area intruded by sills, and to a small extent by dykes, of basic to intermediate igneous rocks. The Collinsville area has not escaped, as reference to the plates showing the sections of the seams in bores will emphatically show. All of the seams listed previously have suffered badly, and not always in identical areas. Seams are affected where there is no surface evidence of igneous rocks, and this circumstance, combined with deductions derived from plotting out the igneous occurrences in the bores, shows that the change is probably wholly affected by sills which may work from one seam to another by an intermediate dyke. The damage is therefore much more extensive than would have been accomplished merely by dykes. As an extreme illustration of this the Scott Seam has been found either wholly or partially destroyed in all bores passing through it between depths of 45 ft. and 475 ft. below the surface, over a distance along the strike of the seam of 4½ miles. As the seam averages nearly 6 ft. thick throughout that distance it can be seen what irreparable loss the field has suffered when this is but one instance, and all the seams have been affected in a serious degree.

The erratic occurrence of these intrusions will render imperative, if financial considerations are not ignored, the core drilling of any area which is intended to be worked at or around Collinsville at any great depth, before expenditure on shafts would be justified.

Disturbance of Coal at Collinsville.

The Collinsville coal is being worked at present on an area of the field with a gentle south-east to south-west dip (usually about 7 degrees) which extends east and west for about 3 miles in length before sharp folding on its eastern end terminates this slightly inclined area. A narrow syncline then runs north-west to south-east, and this is in line with highly inclined to vertical strata traced at intervals from Mount Devlin to Jack's Creek, a distance of 15 miles. The disposition of the marine beds in this syncline can only be accounted for by overthrust faulting, since a thickness of about 500 ft. to 600 ft. only is represented on the western side, while on the eastern side from 200 ft. to 250 ft. only are present. The pitch of the syncline is to the south-east, and this would account for the series in traverse sections showing progressively thinner to the north-west. Exposures of the marine strata are not sufficiently good to determine the exact thickness involved, nor the amount of faulting, but it is certainly the lower beds of the series as exposed at Collinsville which appear on both sides of the fold. The Big Strophalosia horizon has not been identified, as such, in the fold north of the pumping station, although this fossil occurs in beds 150 yards east of D. B. Fidler's store, dipping north-east at 50°. On the reverse side of the fold the

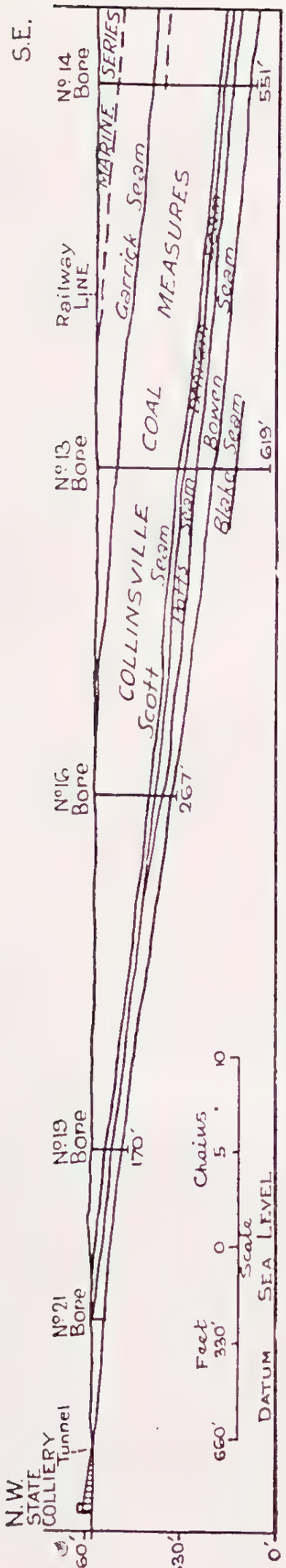


Fig. 10 (*a*).—Section from State Colliery to No. 14 Bore, showing Dip of the Coal Seams.

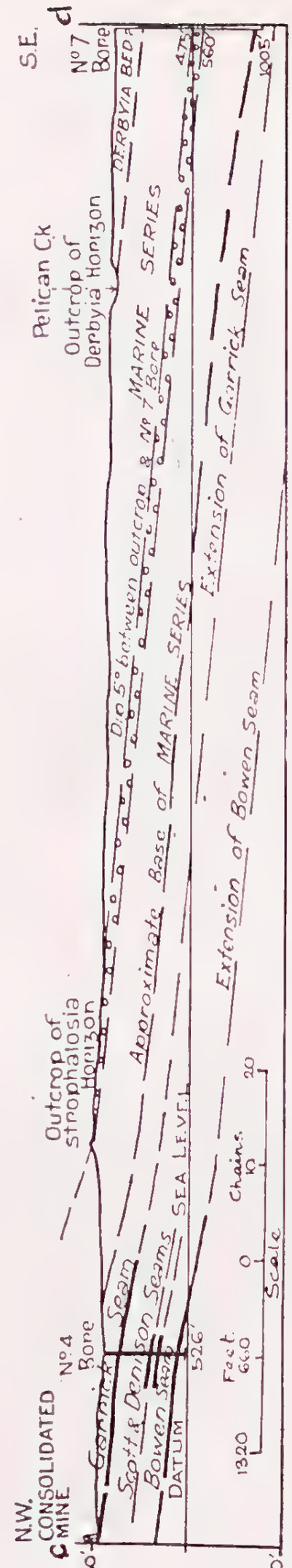


Fig. 10 (*b*).—Geological Section along Line *c–d* on Collinsville Map.

exposures in Carpet Snake Creek and gullies, just behind the railway station, can be identified as portion of the 300-ft. zone below the Big Strophalosia bed, which is characterised by ironstone bands with *Agathiceras, Mourlonia, Chænomya,* &c., all of which are found abundantly there. These beds dip gently to the south-east at about 15°, but followed south along the creek become most irregular in strike. The disparity in thickness of the marine strata suggests that there has been overthrust faulting involving a movement of 300 ft. at least, but probably more. The marine beds occupy a width of 20 to 25 chains, and on either side of them are the underlying coal measures. These are exposed on the eastern side in a small cutting about 100 yards north of the railway station (dip 80 degrees to the S.W.) and are immediately underlain by rhyolitic tuffs which cut across the railway line and then cross Pelican Creek half-a-mile lower down. This rhyolite horizon (Lower Bowen) is conspicuous in a parallel ridge, 60 chains further west on the other side of the syncline, dipping N.E. at 45 degrees. It then takes a right-angled turn and passes behind the State colliery at a distance of 400 yards, dipping south-east there at 10 degrees.

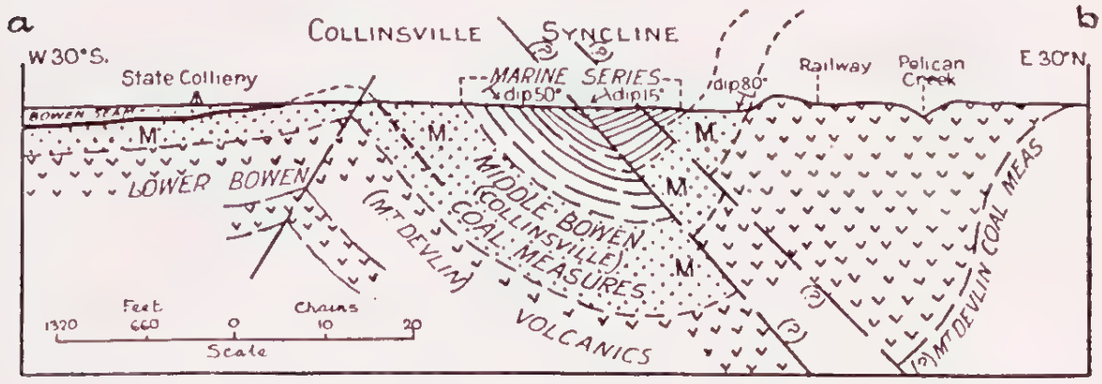


Fig. 11.—Geological Section along Line *a–b*, Collinsville Map, showing Probable Type of Overthrust Faulting.

These sharp bends are reflected in the Lower Bowen beds around Mount Devlin, 2½ miles further north. The dips are steep on all N.W.-S.E. striking strata and very slight on those striking N.E.-S.W. The State Colliery tunnel is located only 18 to 20 chains west of the sharp fold forming the south-western flank of the Collinsville syncline. The north-east levels in this mine can therefore extend only that distance, at the most, on undisturbed coal. The beds at this spot take a "hair-pin" bend without actual dislocation, and this structure is easily traced on the surface by ironstone bands in the shales above the Scott Seam exposed at a spot barely a half-mile south-east of the State Colliery. In the creek 20 chains east of the colliery, it is also seen that coal and shale outcrops, instead of dipping gently to the south-east as in the mine, are turned completely round at right angles and dip at 60 degrees to the north-east.

The effect of this great disturbance on the future working of the Bowen Seam in the State Colliery has been investigated.

The State tunnel has a bearing south, 32 degrees east, which is thus approximately parallel to the line of the disturbance with steep north-easterly dips. A section at right angles to this bearing shows (as in section fig. 12) the intersection of nearly horizontal bedding planes with those inclined at nearly 60 degrees. The intersections of these planes indicate the hade of the disturbance to pitch south-westerly with approximately an angle of 50 degrees from the horizontal. This is confirmed by the record of No. 31 bore which is of interest in that it passes first through gently dipping strata and then into nearly vertical strata. The surface mapping shows this bore to have started in settled strata corresponding in dip to that in the State Colliery, but that at 5 chains to 6 chains east of it the disturbance reaches the surface since the strata in Carpet Snake Creek, about 7 chains to the north, dip N.E. at 60 degrees. The bore (*see Fig.* 12) starts on or about the horizon of the Garrick Seam, and the Scott (228 ft.), Denison (244 ft.), and Potts (272 ft.) seams are picked up with

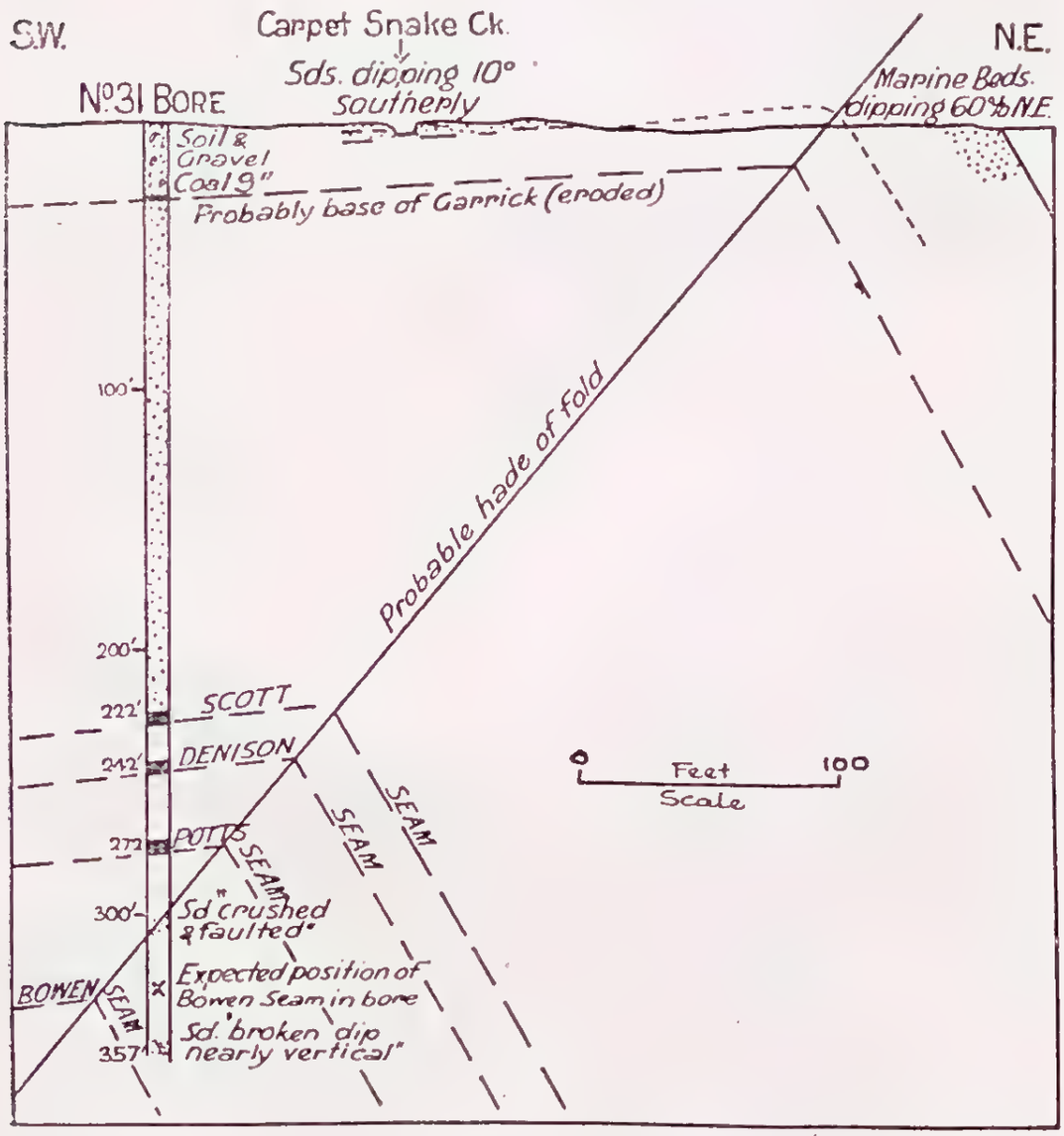


Fig. 12.—Diagrammatic Section illustrating Disturbance of the Coal Seams near State Colliery, and explaining Absence of Bowen Seam in Bore No. 31.

their usual interval. The Bowen Seam should have been normally passed through at about 330 ft., but at 315 ft. the record shows "crushed and faulted strata." There is no record of coal below this so that the Bowen Seam is missing from its expected position, and the bore terminated at 357 ft. in "very broken strata dipping nearly vertical" according to the record of Mr. Vale, the driller. The plotting of the surface data and the bore data, in conjunction, shows the hade of the disturbance (fold) inclining south-westerly at an angle of about 48 degrees at this spot.

The tunnel on the Bowen Seam as it is followed down the dip in the State Colliery, is gradually converging on the line of the disturbance, so that it may, if continued on its present direction, eventually run on to the crest of the anticline, which is defined at the surface, on the map of Collinsville, by the position of the Big Strophalosia horizon, and become somewhat flatter in inclination. The anticline itself plunges at a slight angle to the south-west, so the tunnel in following the coal in its present direction would never become absolutely flat, even when on the crest of the anticline. The dip of the Bowen Seam between Bores Nos. 13 and 14 has become slightly flatter, and the contours of that seam, as approximately determined by the depths at which it is struck in No. 14 (530 ft.) and No. 15 (557 ft.) bores, shows that the seam at No. 14 is dipping to the south-west instead of south-east as in the present mine workings. In the No. 1 east level at a point 11 chains east of the tunnel the seam starts to roll, slickensides become evident, and there are slight overthrust faults in the seam in the vicinity. The level swings round to a south-east course following the altered strike of the coal seam and dips at a steeper angle, 20 degrees to 25 degrees to the south-west, as against 7 degrees or 8 degrees nearer the tunnel. The coal here is not considered worth mining at present, as the crushing to which it has been subjected is stated by the manager to have deteriorated it. As all the other evidence cited previously pointed to the tunnel eventually running on to the anticline, and consequently more or less disturbed coal, the south-west dip of the seam between bores 14 and 15, on the west side of the tunnel, may be an indication of the fact that the start of the disturbance as noted above in the No. 1 east level has crossed the projected line of the tunnel, probably in the vicinity of the No. 13 bore, and to the south-east of it there is every reason to expect a reproduction of the same conditions which have affected the quality of the coal in No. 1 east level at 11 chains from the tunnel. Also each succeeding east level as the seam is followed down should have a diminished length in which the coal will not show the effects of the crushing. It is to be noted that the intensity of the folding movement increases progressively northerly as the lower beds are exposed, until, on this line of folding, the Lower Bowen beds (Mount Devlin coal measures) attain a vertical position on the road immediately to the north-west of Mount Devlin itself.

The syncline east of Collinsville must be faulted to account for the partial disappearance of the marine beds on the north-eastern side, and the probabilities are that there are one or more overthrusts of some magnitude parallel to the fold axis. It is considered that the coal seams in this area will be found too severely crushed and faulted to have any commercial value.

Port Denison Coal Company's Bore (No. 7).

This diamond drill bore is situated to the south of Pelican Creek about three-quarters of a mile N.N.E. of Sonoma Homestead, and was sunk some years ago to a depth of 1,005 ft. without

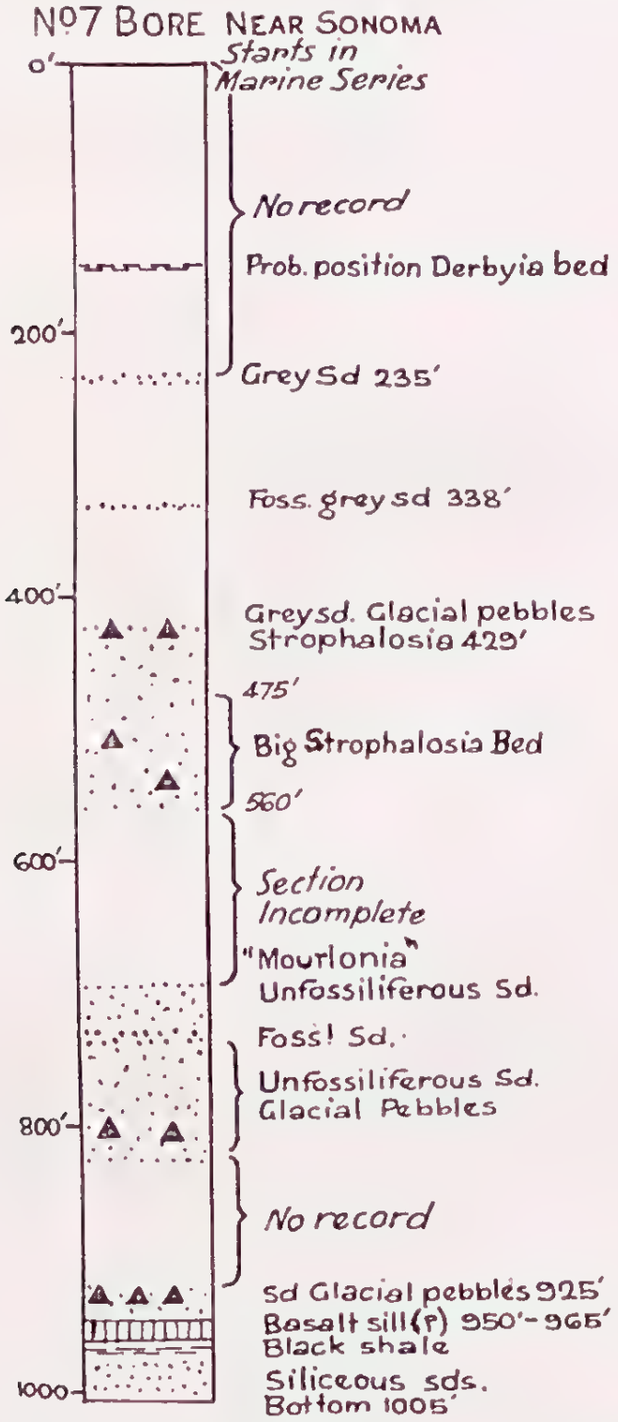


Fig. 13.—Diagram (incomplete) of No. 7 Bore, Port Denison Coal Company, Depth 1,005 Feet.

striking coal. Samples of the core selected by the company's driller were forwarded at that time to the Geological Survey, but the core record is incomplete and, on the whole, unsatisfactory. It furnishes some useful information, however, as to several marine horizons, and gives some clue therefore to the depth of the coal seams in that area. The situation of the bore is 30 chains south-east of the outcrop of the Derbyia horizon in Pelican Creek, and this bed would be probably passed through at a depth of about 140 ft., but there is, unfortunately, no record of this portion of the bore. From 475 ft. to 560 ft. all portions of the core represented are marked by the presence of *Strophalosia,* and there can be little doubt that this is the Big Strophalosia horizon, and it appears to be 85 ft. thick there. As the bore position is about 150 ft. lower in level than the outcrop of this bed near Scottsville, the dip of this bed in the distance of 1½ miles is equal to 625 ft., giving approximately an angle of dip of 5 degrees throughout the section. Glacial pebbles and occasional marine fossils occur at intervals to 925 ft. The core from 950 ft. to 960 ft. consists of basalt which probably occurs as a sill. Below this is a thin bed of black shale and then rather siliceous sandstones to the bottom of the bore at 1,005 ft. The base of the marines, it is thought, cannot be less than 950 ft., and probability is slightly lent to this by the occurrence of a large decomposed sill in the bores south of Collinsville—Nos. 14, 17, &c.—at or near the base of the marine series there. Marine fossils are recorded 20 ft. above it in those bores. On the thickness of 300 ft. of strata observed to intervene between the Big Strophalosia bed and the base of the Marine Series near the Bowen Consolidated mine, the base of the series in this bore should be expected at 860 ft., but there is undoubted evidence of marine beds to 930 ft. at least. It therefore appears that the beds below the Big Strophalosia horizon have increased in thickness in the distance of 1½ miles to the extent of 70 ft. to 90 ft., or that the beds are overlapping gradually to the north. The siliceous sandstones from 970 ft. to 1,005 ft. resemble more the coal measures sandstones, or the basal marine sandstones as developed in other portions of the field. The depth of the Garrick Seam cannot therefore be determined accurately on the site of this bore, as there is some uncertainty as to where the base of the Marine Series occurs, but it is pretty certain that the bore had already penetrated in the coal measures, and that the Garrick Seam could hardly be more than 100 ft. below where boring ceased, while possibly it would have been reached in less than that distance.

Quantities of Coal.

Of an area of approximately 1,700 square miles, comprising the entire coalfield, only a portion consisting of about 20 square miles has been prospected and to a slight extent developed. This area has been geologically surveyed, 26 bores, of which records are available, have been drilled, either by the Government or private companies, and two collieries are at present working

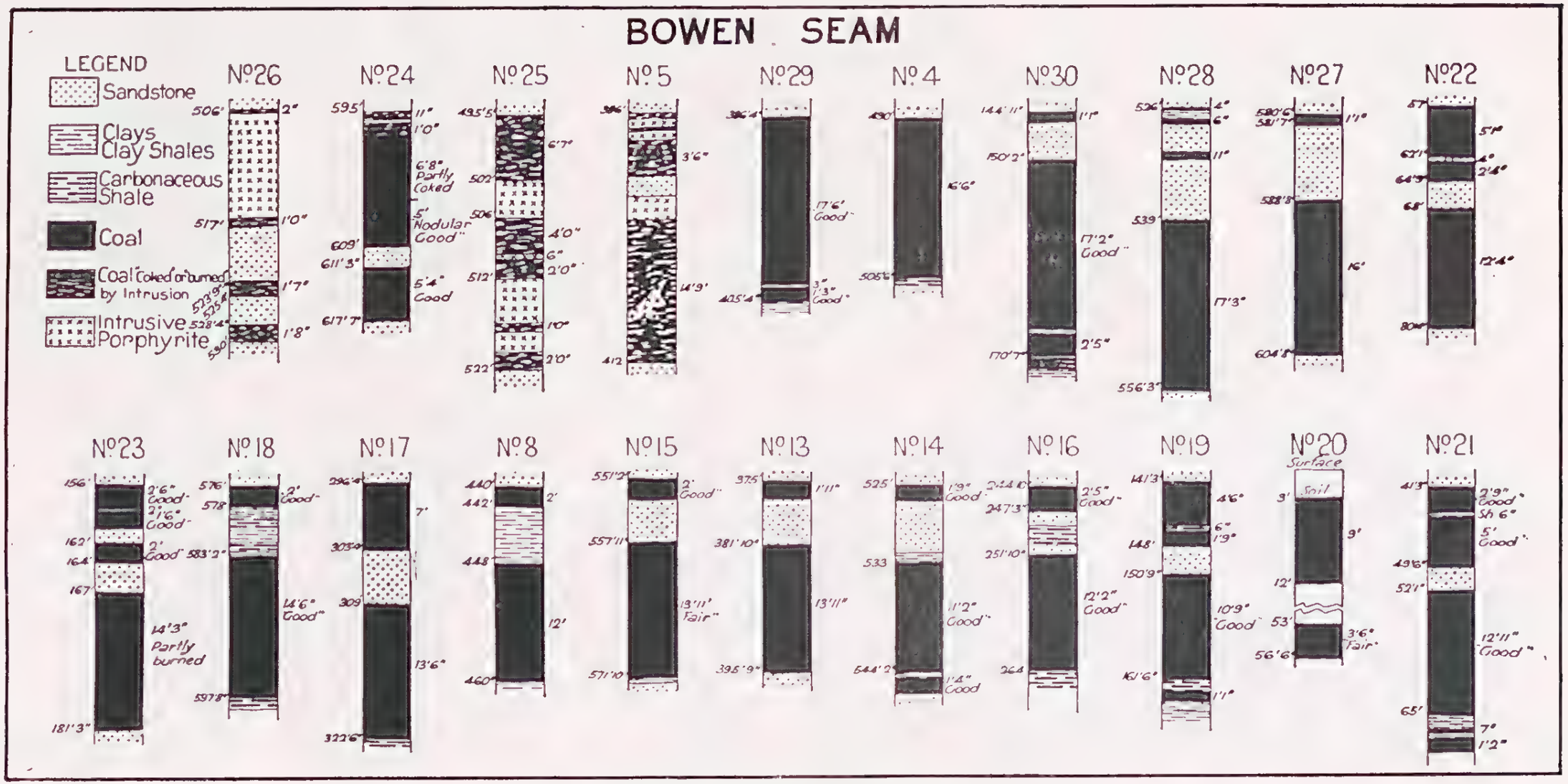


Fig. 14.—Sections of Bowen Seam in Drill Cores.
(See Fig. 9 for Bore Locations.)

on it. It will be seen from the estimated quantities within the drilled area, quoted later, that, assuming the seams continue over the whole basin, there would be almost inexhaustible quantities of coal on the field. The Collinsville Coal Measures, however, have not yet been proved to exist in the whole of the coalfield as mapped, but from the mapping of them on both sides of the northern portion of the basin, it is reasonably certain that they at least underlie a superficial area of about 400 square miles, being the northern portion of the 1,700 square miles covered by reconnaissance mapping. It is not known whether the seams, as they exist near Collinsville, are continuous through this area, but as several coal outcrops have been reported in these measures near the Bowen River it is rather probable that coal occurs throughout this extension of the basin, and future reserves above a depth of 4,000 ft. may possibly be of very great dimensions. In addition, there is the possibility of large reserves in the Upper Bowen Coal Measures, for coal outcrops in them have been recorded by Jack at Havilah, the Bowen River, and Jack and Macarthur Creeks, although these are apparently not promising for development on account of their intrusion by igneous rocks. It is practically certain that any coal seams in either the Middle or Upper Bowen Coal Measures will be found to be much intruded in this area of 400 square miles, and it is anticipated that favourable areas for working will be located only after diamond drilling has tested the seams.

Possible Reserves between Pelican Creek and Bowen River. —This potential coal-bearing country, about 120 square miles in extent, is a direct continuation of the Collinsville field towards the south, and forms portion of the 400 square miles just discussed. The outcrops of the coal measures have been mapped to the Bowen River on both sides of this synclinal basin—i.e., encircling it except on the southern boundary. The continuity of the six principal seams has been proved by survey work, and drilling, to extend from Collinsville township to 1 mile south of No. 1 bore, a distance of 14 miles parallel with the seams' outcrops, and to depths up to 800 ft. None of the seams show any indication of thinning out at either end, except possibly the Bowen Seam between No. 1 and No. 26 bores, nor in the deeper bores. Coal outcrops have been reported close to the opposite extremity of this area near the Bowen River (*see page* 60) which indicate that seams probably continue throughout it in these coal measures.

No boring south of Pelican Creek has been done in these measures, so the thickness of coal contained is not therefore known, but the seams in the aggregate are known to average 48 ft. thick on the north side of this creek, and are dipping between east and south into this area. Taking a conservative estimate of the thickness of the coal (also entirely omitting any estimate of the Blake Seam as of dubious commercial quality) likely to extend under this area, and making equal deductions

to those at Collinsville for coal destroyed by intrusions, it is considered that there may be a possibility of this continuation of the coal measures between Pelican Creek and the Bowen River containing reserves of not less than 1,000 million tons of workable coal to a depth not exceeding 4,000 ft..

Collinsville Seams.—Some statistical data as to quantities may be useful in forming a conception of the relative importance of the coal field, therefore the following figures are submitted. The average thickness of the most important seams in the prospected and partly developed area of about 20 square miles at Collinsville as calculated from the Government bore records and several private bores is as follows:—Blake 13 ft. 6 in., Bowen 14 ft., Potts 3 ft. 6 in., Denison 5 ft., Scott 6 ft., Garrick 6 ft. 9 in. Total average thickness 48 ft. 9 in. The thickness of the Blake Seam is, however, based on incomplete data, as only five bores have penetrated it. The thickness of the Bowen Seam includes the Vale Seam as noted in the drill records. The Vale appears to be an upper section of the Bowen Seam, and appears to be of importance only in the No. 1 State area, where it is usually only several feet thick, though it attains 7 ft. in one bore (No. 17).

Estimates of only actual, highly probable, and probable reserves are included within the following general estimate of coal reserves at Collinsville. Total and probable available tonnages on this basis are quoted. They are based for convenience on tonnages of 1,500 and 1,000 per foot acre of coal respectively. The disparity between the estimates under these headings will be noted, and it must be mentioned that any estimate of available quantities is exceedingly difficult to make and somewhat uncertain. After allowing a one-third deduction for loss, &c., in mining operations, a further, and uncertain, deduction has to be made on this field for the coal affected or destroyed by igneous intrusions. These are practically all sills, but their boundaries are irregular, and where drilling records at close intervals are not available, considerable error is certain to intrude, and on that account the estimates of available tonnages must be considered as tentative and subject to future alteration.

The area of approximately 20 square miles which has been surveyed and drilled, and to which the estimates in the following table refer, lies on the north side of Pelican Creek between No. 1 Bore and the township of Collinsville, and includes State Reserves Nos. 1 and 3 (in part), No. 2 (completely) as well as M.L.'s 32, 46, and 49. The seams outcrop through this area, so that considerable portions of it do not contain the higher seams.

Estimate of Coal Reserves in the Defined Collinsville Area (within approximate area of 20 square miles).—This table

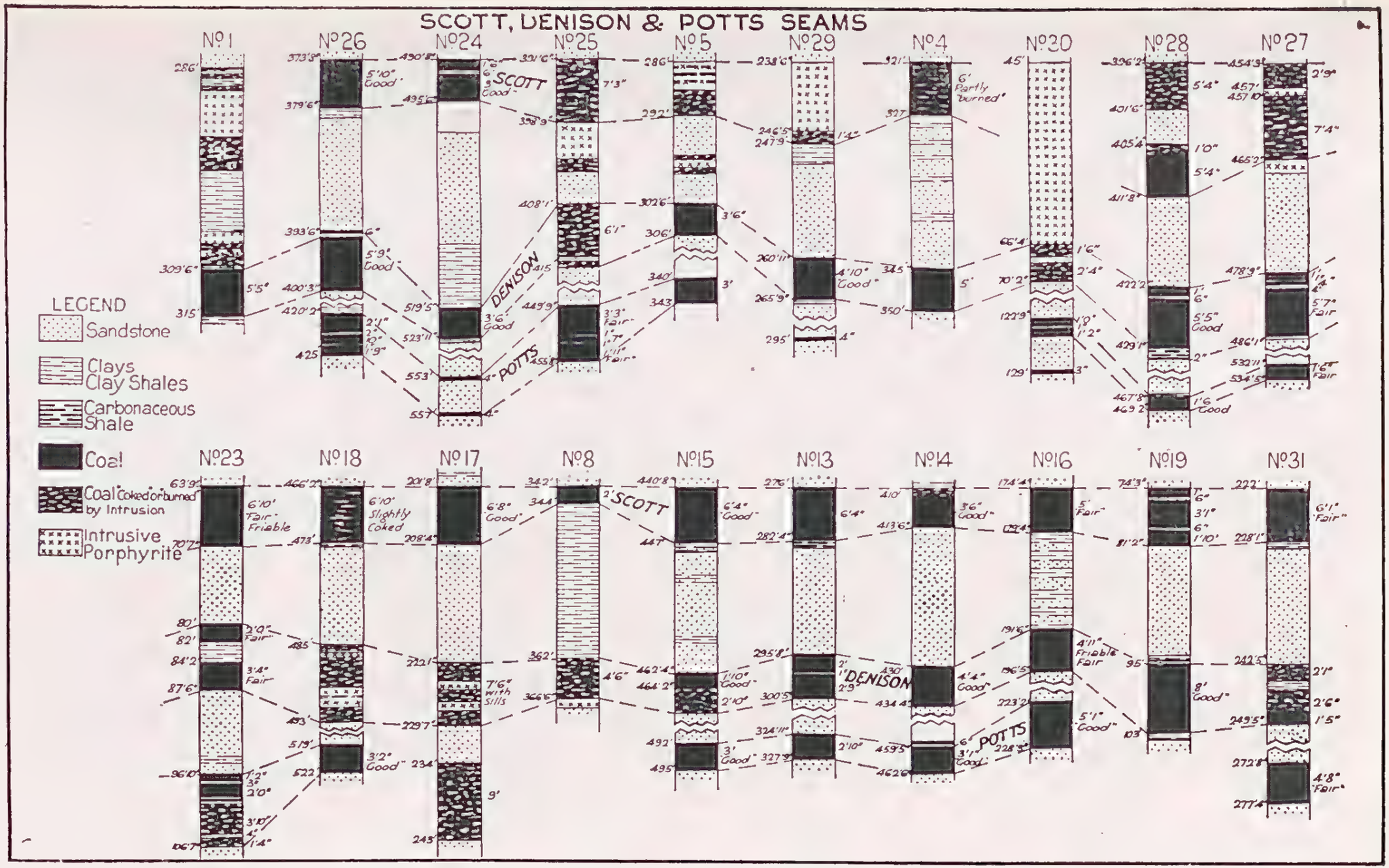


Fig. 15.—Sections of Scott, Denison, and Potts Seams in Drill Cores.

includes coal which may be regarded as actual and probable tonnages.

Seam.	Total Tonnage.	Probable Available Tonnage.
Garrick	48,300,000	13,800,000
Scott	67,460,000	17,700,000
Denison	62,560,000	19,120,000
Potts	17,040,000	5,500,000
Bowen	136,700,000	40,760,000
Blake	87,680,000	13,660,000*
Totals	419,740,000	110,540,000

** Probably understated, data incomplete as to tonnage likely to be affected by intrusions. Coal in this seam probably too inferior for present-day operations.*

Probable Reserves between Collinsville Area and Pelican Creek.—On the northern side of Pelican Creek there is an area of about 5 square miles lying between Three-mile Creek and State Reserve No. 1, and adjoining State Reserves Nos. 2 and 3, which has not yet been taken up for coal-mining. It can be considered as an area containing probable reserves of coal, since no portion of it is more than 2 miles from the nearest bore, and the seams, besides being regular, have been traced to half encircle it and proved to dip towards it. The Bowen Seam should not exceed a depth of 1,400 ft. in any portion of this area, and the other seams will be considerably less. Omitting the Blake Seam from consideration as of doubtful commercial quality, and allowing 30 ft. as a conservative aggregate thickness for the five remaining seams, there is a probable total tonnage of coal in this area of 144,000,000 tons, additional to the actual and probable tonnages quoted above for the Collinsville area. Allowing the same deductions from these seams as in the adjoining Collinsville area, the probable available tonnage would be 42,000,000 tons.

State Reserve No. 1.—Area 4,570 acres, situated between Collinsville, Scottsville, and Sonoma. Of this area the north-eastern strip about 60 chains wide, and containing about 1,100 acres, is much folded and faulted, and most of it will certainly be found to be too highly disturbed for the seams to have much value there. As this strip is followed to the south-east corner, the disturbance becomes less acute. This crushed area can be detected, at the surface, to start about 18 chains east of the State Colliery, and the effects of it have been noticed underground in No. 1 east level at 11 chains east of the State Colliery tunnel, where the quality of the coal is adversely affected, and where the seam changes its direction of strike and dips more steeply (up to 25 degrees), these being the first underground indications of the very acute fold-over towards the east. The remainder of the reserve, about 3,470 acres, will be found to be unaffected by this disturbance, and dips of the order of 1 in 6 to 1 in 10 will be found throughout it. Of this area about 1,800 acres between

Scottsville and Collinsville have been tested by diamond drill bores, and the anticipated reserves of coal are as follows:—

Seam.	Area.	Average Thickness of Seam.	Total Tonnage.	Available Tonnage.
	Acres.	Feet.		
Garrick	1,000	6	9,000,000	6,000,000*
Scott	1,500	5·5	12,375,000	Probably small†
Denison	1,500	5	11,250,000	Probably small†
Bowen	1,800	14	37,850,000	25,200,000*

** No deduction made for tonnage affected by intrusions, which probably will be slight.*
† Much affected by intrusions.

The balance of the reserve, 1,680 acres, lying in the south-western corner appears to be a very suitable area for future working. The Garrick Seam should be found there varying between depths of 450 ft. and 1,150 ft., and the Bowen Seam between 800 ft. and 1,500 ft. This area has not been bored at all, so that the thickness of each seam is not known; but assuming that the two principal seams continue to dip through this area without diminishing in thickness, it would contain the following additional total tonnages based on those figures:—

Garrick Seam	15,120,000 tons
Bowen Seam	35,280,000 tons

The risk of coal not being available on this area for future mining is mainly confined to (1) the thinning or deterioration of the seams, (2) the destruction of coal by intrusive rocks. As to the first, it is considered improbable that the seams will seriously thin out in view of the boring data available on other areas in this portion of the field. As to the second, this can always be considered a possible menace in this district which must be guarded against in an area like this, where the seams occur at moderate depths, by a considerable amount of drilling before the sinking of any shafts to win coal is undertaken. There is little, if any, surface evidence of intrusive rocks in this area, which is certainly in its favour, but this can be misleading and, despite its absence, the seams underneath may be considerably destroyed or affected.

State Reserve No. 2.—Area 2,558 acres. The centre of this reserve lies 5½ miles south-west of Collinsville. There are three widely spaced bores (Nos. 24, 25, and 26) in the northern half of it, so that the southern half remains so far untested. The Blake Seam was reached in bores Nos. 24 and 26, but was found to be almost entirely destroyed. The Bowen Seam is almost entirely destroyed in the three bores, and the Garrick is destroyed in Nos. 24 and 25, while in No. 26 there is only a section of coal 3 ft. 4 in. thick with thin coal bands above and below that. Both the Scott and Denison Seams are destroyed in No. 25 bore (the most northerly), but in Nos. 24 and 26 they have workable thickness of coal unaffected by intrusive rocks. The respective thicknesses in these two bores are:—Scott Seam, 5 ft. 10 in. and

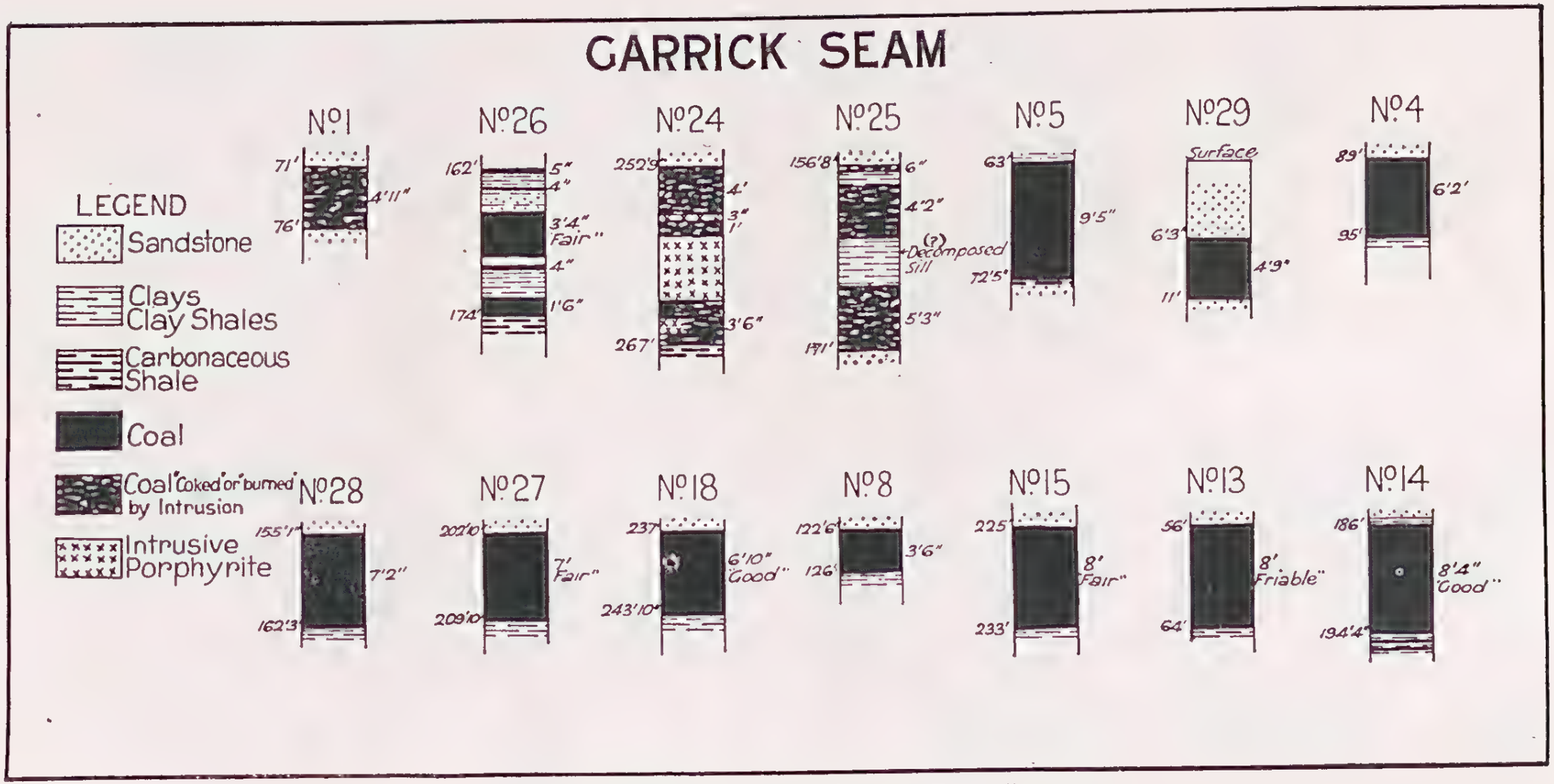


Fig. 16.—Sections of Garrick Seam in Drill Cores.

4 ft. 6 in.; Denison Seam, 5 ft. 9 in. and 3 ft. 6 in. The reserve on this evidence appears a most unfavourable area on which to attempt to develop either the Blake, Bowen, or Garrick Seam. There is insufficient boring evidence to indicate whether the Scott and Denison will be worth working in the future, but a bore in the centre of the area and one near the south-eastern boundary should be sufficient to determine that question in the future.

The coal measures are only very slightly tilted and occupy a slight trough which dips south-east at about 1 in 12. Consequently, the seams will be found at shallow depths, and these can be approximately determined at their deepest points owing to the outcrop of the key horizon of the seams—the Big Strophalosia bed—occurring close to, and parallel with, the south-eastern boundary. The Garrick Seam, it is anticipated, will be found in this reserve within the depths of 100 ft. and 500 ft., and the Bowen Seam from 330 ft. to 380 ft. deeper.

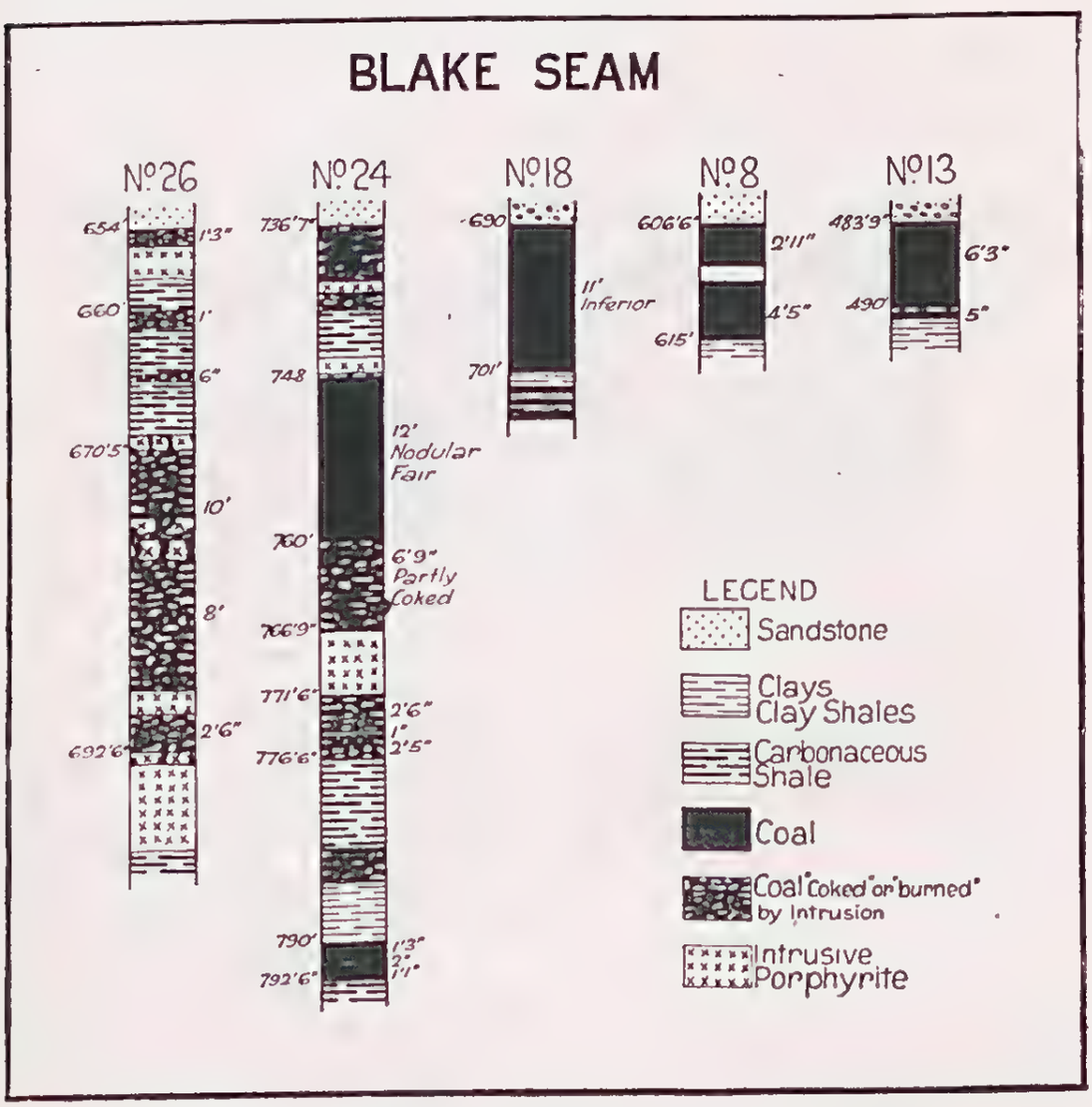


Fig 17.—Sections of Blake Seam in Drill Cores.

State Reserve No. 3.—Area, 7,676 acres. This extends along the north-west and north-east boundaries of State Reserve No. 2 and adjoins the north-west and south-west boundaries of M.L.'s 46 and 32 (Bowen Consolidated Coal Co. leases). Prospects look

very unfavourable here for any considerable areas of workable coal on any of the seams, although an area of 640 acres joining M.L. 32 on the south-west has not yet been tested. The area is more or less highly intruded. One sill, for instance, about 50 ft. thick, lying above the outcrop of the Bowen Seam, can be traced for a mile at the surface. An outcrop of the Blake Seam is also intruded. In addition, every private bore that has been put down, of which records are available, has passed through intrusive rocks, in many cases in contact with coal seams. It was in this area that practically all the initial prospecting on the field was carried out by a number of private companies with disappointing results. Bores Nos. 5 and 25 indicate how badly all the seams are affected in certain portions of this reserve in addition to the surface evidence of intrusions in other parts of it.

Fig. 18.—Bowen Consolidated Mine, Scottsville.

Bowen Consolidated Leases.—These consist of M.L.'s 49, 46, and 32, each approximately 1 square mile in area. The Bowen Seam apparently underlies the whole of these leases, and the Garrick Seam about half of their total area. The Coal Measures in the 3 square miles will be found to be practically undisturbed, and the seams should be found dipping gently between south-east and south-west at a grade of 1 in 7 to 1 in 9 throughout. The boring on these leases indicates that the Bowen and Garrick Seams have not been detrimentally affected by intrusive rocks in nearly half of their total area. The Scott Seam has been destroyed in all bores on the three leases, but the Denison has escaped, except in No. 30, near its outcrop.

M.L. 49.—The Bowen Seam should be found to be free from any extensive deterioration by intrusive rocks, with the possible exception of the western corner, and will average about 16 ft. thick throughout. The Scott Seam is destroyed by intrusions

in the only three bores on this lease. The Garrick Seam averages 7 ft. thick. On these thicknesses anticipated quantities of coal are as follows:—

Seam.	Area.	Average Thickness.	Total Tonnage.	Available Tonnage.
	Acres.	Feet.		
Garrick	240	7	2,520,000	1,680,000*
Scott	480	6	4,320,000	Probably nil
Denison	500	5·5	4,125,000	(?) †
Bowen	600	16	14,400,000	9,600,000*

* *No deductions made for tonnage affected by intrusions which will probably be slight.*
† *Destroyed in No. 30 bore, but unaffected in Nos. 27 and 28.*

M.L. 46.—There is every likelihood of the seams, in the northern half at least, of this lease being more or less detrimentally affected. This is on account of surface indications of intrusive sills in Dyke Creek, about half a mile north-west of the mine, and outcrops of similar rocks near the north-western boundary, as well as the fact that the Scott, Denison, and Bowen Seams are shown to be each intruded in Bore No. 5 (No. 3 State Reserve). The lease, however, has not been bored on except by No. 29 bore, so that actually its potentialities in workable coal remain unknown, although there is sufficient evidence to warrant thinking they will be the least of the three leases. The Bowen underlies nearly the whole of the lease, the Scott and Denison about three-fourths of the lease, and the Garrick an area of about 150 acres in its southern corner.

M.L. 32.—This lease will probably be of great value, but the coal in it has not been proved except in the northern corner near the mine tunnel by bores Nos. 4 and 29. The Garrick, Denison, and Bowen Seams are unaffected by intrusions in these bores, but the Scott is destroyed in both. The seams throughout the 640 acres will be found to dip gently to the south-east at grades of 1 in 7 to 1 in 9, and will be free from any large disturbance. It will probably prove to have a greater potential value than M.L. 49, but it is not yet proved to the same extent as that lease is. The Garrick Seam is of very indifferent quality near the outcrop in the mine workings, particularly to the south-west of the tunnel. It has improved very much on the dip, however, being almost free from bands in a 7 ft. 6 in. section of coal, although the bottom 2 ft. consists of very soft and friable coal. This improvement will probably be maintained for another 15 chains at least on the dip, as the No. 4 bore showed 6 ft. 2 in. of very fair quality of coal. Assuming the Garrick and Bowen Seams average 6 ft. and 16 ft., respectively, throughout, the total tonnage in this lease from these two seams would be about—

Garrick Seam .. .. .. 5,500,000 tons.
Bowen Seam .. .. .. 15,000,000 tons.

What the available tonnage is likely to be, it is impossible to predict in the absence of boring, since it is a reasonable possibility that portions of the seam may be found to be partly affected or destroyed by intrusions. The Big Strophalosia bed outcrops through the centre of this lease, so the approximate depths to the seams below can be easily determined for almost any portion of the lease on the data supplied in this report.

Character of Coal.

The Collinsville coal of the Middle Bowen Formation is a bituminous coal of low to medium volatile content, and on that account its combustion forms a lighter smoke than normal bituminous coals. There is little variation in the average composition of the coal from the five different seams (excluding the Blake Seam, of which only one analysis is available). Occasionally an analysis shows an usually low volatile content, but in a number of cases this has proved to be coal adjacent to an intrusion, and these few abnormal analyses have been excluded from the following estimations of available analyses.

The following table shows the composition and fuel ratio on a pure coal basis of the different seams:—

Seam.	Number of Analyses of whole Seam.	Volatile Hydrocarbons.	Fixed Carbon.	Fuel Ratio.
Garrick	8	24·3	75·7	3·1
Scott	2	25·0	75·0	3·0
Denison	5	25·0	75·0	3·0
Potts	3	24·3	75·7	3·1
Bowen	6	22·5	77·5	3·4

The Bowen and Garrick Seams are the only ones that have been worked, although the coal from the other three seams is indicated by the analyses to be of about the same quality as the two former.

The Garrick coal is often soft and makes much slack. The samples from it taken at the Consolidated mine were also high in sulphur. These two features both limit its adaptability as fuel since they conduce to spontaneous combustion, and so far it does not appear to be suitable for bunker coal nor for export. As laboratory tests indicate it likely to be a good coking coal, its future use probably lies in coking, possibly after a washing process to reduce sulphur and ash. Run-of-mine coal from areas free from intrusive rocks may be expected to approximate 13 to 15 per cent. ash.

TABLE 1.—COAL ANALYSES FROM SEAMS IN THE COLLINSVILLE COALFIELD.

Location	Seam.	Depth.	Thickness Sampled.	Moisture.	Volatile Matter.	Fixed Carbon.	Ash.	Sulphur.	Calorific Value. B.T.U.	Calorific Value. Evaporation.*	Coke.	Collector.	Date.
Bore No. 4 (formerly Towers-Bowen Coal Co.)	Garrick..	89′	6′ 2″	1·3	15·2	67·0	16·5	..	..	..	Fairly hard, non-lustrous and with little porosity	P. F. Nielson	29/5/1914
State Reserve No. 2	ditto ..	..	..	0·9	23·5	66·5	9·1	..	13,860	14·37	Porous and fairly hard coke	..	14/4/1915
Formerly C. P. A. 16 (Bowen C. and C. Co. Shaft)	ditto ..	38′ ?	(top) 5′	1·2	20·2	63·2	15·4	..	12,632	13·09	Hard fairly porous coke	Bowen Coal and Coke Co.	..
Bore No. 5 (formerly Bowen Coal and Coke Co.)	ditto ..	63′–65′	(bot.) 5′ 8″	1·2	21·7	67·1	10·0	..	13,597	14·09	ditto	ditto ..	..
			2′	1·1	18·0	58·0	22·9	..	11,703	12·13	Hard lustrous and porous coke	..	20/1/1915
		65′–67′	2′	1·0	16·6	53·2	29·2	..	10,487	10·87	Hard coke	..	20/1/1915
		67′–69′	2′	0·7	18·4	53·0	27·9	..	10,721	11·11	ditto	..	20/1/1915
		70′–71′	1′	0·7	18·5	57·0	23·8	..	11,437	11·85	Hard coke fairly porous	..	20/1/1915
		71′–72′	1′	1·0	23·3	65·3	10·4	..	13,711	14·02	Hard porous coke ..	..	20/1/1915
Bore No. 14	ditto ..	186′–194′ 4″	8′ 4″	1·5	19·3	61·4	17·8	0·7	11,794	12·2	Coke of poor quality ..	J. H. Reid ..	10/4/1924
Bore No. 18	ditto ..	237′–243′ 10″	6′ 10″	1·5	22·8	66·4	9·3	1·2	13,262	13·7	ditto	ditto ..	10/4/1924
Consolidated Mine	ditto ..	No. 2 east	7′ 4″	0·8	22·4	63·5	13·3	3·1	13,000	13·5	Coked	ditto ..	16/5/1924
		No. 3 west	7′ 4″	0·7	21·9	64·4	13·0	4·1	13,117	13·6	ditto	ditto ..	16/5/1924
Bowen River Coal Co. Shaft ..	Scott ..	..	(top) 6′	3·3	16·1	67·3	13·3	..	..	..	Forms a hard coke with little porosity	L. R. Blake..	—/8/1914
			(next) 5′	0·9	16·8	69·7	12·6	..	..	..	ditto	ditto ..	—/8/1914
			(next) 5′	1·3	11·0	72·7	15·0	..	..	..	Does not coke	ditto ..	—/8/1914
			(bot.) 5′	1·3	8·3	65·6	24·8	..	..	..	ditto	ditto ..	—/8/1914
Bore No. 17	ditto ..	201′ 8″–208′ 4″	6′ 8″	1·4	19·2	58·6	20·8	0·6	11,579	12·0	Coke of poor quality ..	J. H. Reid ..	10/4/1924
Bore No. 26	ditto ..	373′ 8″–379′ 6″	5′ 10″	1·7	22·3	65·7	10·3	1·1	13,246	13·7	ditto	ditto ..	10/4/1924
Bore No. 4 (formerly Towers-Bowen Coal Co.)	Denison	345′	5′	0·8	17·5	66·5	15·2	..	..	..	Forms a hard coke ..	P. F. Nielson	8/9/1914
Bore No. 5 (formerly Bowen Coal and Coke Co.)	ditto ..	302′	3′ 6″	1·1	8·6	74·6	15·7	..	12,553	13·01	Did not coke	?	10/3/1915
Bore No. 1	ditto ..	311′	5′ 5″	1·15	20·25	61·57	17·03	..	..	..	Coke bright and firm ..	..	1885
Bore No. 14	ditto ..	430′–434′	4′	1·4	22·8	60·9	14·9	1·7	12,296	12·7	Coke of poor quality ..	J. H. Reid ..	10/4/1924
Bore No. 16	ditto ..	191′ 6″–196′ 5″	4′ 11″	1·2	22·2	59·6	17·0	1·1	12,125	12·6	ditto	ditto ..	10/4/1924
Bore No. 26	ditto ..	394′ 4″–399′ 8″	5′ 4″	1·4	21·7	63·8	13·1	0·8	12,942	13·4	ditto	ditto ..	10/4/1924
Bore No. 5	Potts ..	340′	3′	1·0	17·9	57·1	24·0	..	11,316	11·73	Hard porous coke ..	..	10/3/1915
Bore No. 14	ditto ..	459′ 5″–462′ 6″	3′ 1″	0·9	20·3	65·4	13·4	0·8	12,816	13·3	Coke of poor quality ..	J. H. Reid ..	10/4/1924
Bore No. 16	ditto ..	223′–228′	5′	1·1	21·3	62·4	15·2	1·3	12,269	12·7	ditto	ditto ..	10/4/1924
Brisbane-Bowen Coal Co., No. 1 Shaft	Bowen ..	25′–49′	(top) 0′– 4′	‡									
			4′– 8″	2·0	8·3	76·2	13·5	..	..	..	Does not coke	P. F. Nielson	8/9/1914
			8′–12′	1·5	9·9	74·6	13·5	..	..	..	ditto	ditto ..	8/9/1914
			12′–16′	1·5	13·7	75·0	9·8	..	..	..	ditto	ditto ..	8/9/1914
			16′–20′	1·0	18·6	69·1	11·3	..	..	..	Hard coke	..	8/9/1914
			(bot.) 20′–24′	1·0	15·9	71·1	12·0	..	..	..	Hard coke with little porosity	ditto ..	8/9/1914
C.P.A. 22, now C.M.L. 49 (Bowen Consolidated C. Co.)	ditto ..	(?)	(top) 0′– 5′	0·9	19·3	66·2	13·6	..	12,980	13·45	Good hard fairly porous coke	..	14/4/1915
			(mid) 0′– 5′	0·9	20·0	65·7	13·4	..	13,128	13·61	Hard porous coke ..	..	14/4/1915
			(bot.) 0′– 5′	0·8	19·5	61·8	17·9	..	12,313	12·76	ditto	..	14/4/1915
Bowen Coal and Coke Co., No. 9 Shaft (C.M.L. 41)	ditto ..	27′–57′ †	(top) 0′– 5′	1·0	16·9	58·2	23·9	..	..	..	Hard coke	L. R. Blake..	8/9/1914
			5′–10′	0·9	18·2	61·8	19·1	..	..	..	ditto	ditto ..	8/9/1914
			10′–15′	0·9	19·1	65·9	14·1	..	..	..	ditto	ditto ..	8/9/1914
			15′–20′	1·0	18·0	60·6	20·4	..	..	..	ditto	ditto ..	8/9/1914
			20′–25′	0·8	17·7	61·0	20·5	..	..	..	ditto	ditto ..	8/9/1914
			(bot.) 25′–29′ 9″	1·1	14·1	65·3	19·5	..	..	..	Hard coke with little porosity	ditto ..	8/9/1914
Bore No. 4 (formerly Towers-Bowen Coal Co.)	ditto ..	489′	17′ 6″	1·0	18·8	58·0	22·2	..	..	..	Intumesces but does not coke	ditto ..	8/9/1914
Government Bore 13	ditto ..	381′ 10″–395′ 11″	14′ 1″	0·8	18·5	65·9	14·8	0·92	13,005	12·46	Hard porous coke ..	W. T. Wilcox	15/12/1916
Government Bore 15	ditto ..	557′ 11″–571′ 10″	13′ 11″	1·0	17·2	61·3	20·5	0·62	11,997	12·42	ditto	ditto ..	15/12/1916
Government Bore 16	ditto ..	251′ 10″–259′ 10″	(top) 8′	1·1	19·3	69·2	10·4	0·66	13,583	14·06	Intumescent porous coke	ditto ..	15/12/1916
Government Bore 16	ditto ..	260′ 0″–262′ 6″	(bot.) 2′ 6″	0·9	20·9	58·7	19·5	0·63	12,148	12·58	Hard porous coke ..	ditto ..	15/12/1916
Government Bore 17	ditto ..	309′–317′	(top) 8′	0·7	19·7	67·7	11·9	0·87	13,405	13·88	ditto	ditto ..	15/12/1916
Government Bore 17	ditto ..	317′ 0″–321′ 9″	(bot.) 4′ 9″	0·8	19·7	65·3	14·2	0·71	12,955	13·41	ditto	ditto ..	15/12/1916
Government Bore 14	ditto ..	533′ 0″–540′ 8″	(top) 7′ 8″	..	..	..	13·7	..	..	..	..	..	22/1/1917
Government Bore 14	ditto ..	540′ 8″–544′ 2″	(bot.) 3′ 6″	..	..	..	23·2	..	..	..	..	..	22/1/1917
Government Bore 18	ditto ..	583′ 2″–590′ 8″	(top) 7′ 6″	..	..	..	12·7	..	..	..	..	..	22/1/1917
Government Bore 18	ditto ..	590′ 8″–597′ 0″	(bot.) 6′ 4″	..	..	..	15·5	..	..	..	..	..	22/1/1917
Government Bore 19	ditto ..	150′ 9″–161′ 6″	10′ 9″	..	..	..	14·6	..	..	..	..	..	3/5/1917
Government Bore 21	ditto ..	52′ 0″–61′ 6″	(top) 9′ 6″	..	..	..	11·2	..	..	..	..	..	3/5/1917
Government Bore 21	ditto ..	61′ 6″–65′ 0″	(bot.) 3′ 6″	..	..	..	18·3	..	..	..	..	..	3/5/1917
State Colliery	ditto ..	Run of mine coal	abt. 9′	2·0	21·7	61·7	14·6	..	11,934	12·4	..	Colliery Official	—/1/1924
State Colliery	ditto ..	ditto	abt. 9′	0·8	19·0	65·4	14·8	..	12,591	13·04	..	ditto ..	—/2/1924
Government Bore 18	Blake ..	690′–701′	11′	0·8	17·3	63·9	18·0	0·7	12,098	12·5	Coke of poor quality ..	J. H. Reid ..	10/4/1924
State Colliery—													
No. 1 West Section	Bowen ..	..	abt. 9′	0·9	16·6	67·2	15·3	..	..	..	..	Colliery official	—/8/1927
No. 1 West Section	ditto ..	..	abt. 9′	1·1	18·2	67·4	13·3	..	13,072	13·2	..	ditto ..	—/12/1927
No. 2 West Section	ditto ..	..	abt. 9′	0·8	18·4	68·6	12·2	..	..	..	..	ditto ..	—/8/1927
No. 2 West Section	ditto ..	..	abt. 9′	0·9	17·6	69·6	11·9	..	13,246	13·7	..	ditto ..	—/12/1927
No. 3 West Section	ditto ..	..	abt. 9′	0·7	20·4	62·3	16·6	..	..	..	..	ditto ..	—/8/1927
No. 3 West Section	ditto ..	..	abt. 9′	0·7	17·7	70·1	11·5	..	13,302	13·8	..	ditto ..	—/12/1927
No. 3 East Section	ditto ..	..	abt. 9′	0·8	16·7	65·5	17·0	..	..	..	..	ditto ..	—/8/1927
No. 4 East Section	ditto ..	..	abt. 9′	0·3	18·7	68·6	12·4	..	13,241	13·7	..	ditto ..	—/12/1927
No. 5 Dip Section (38 ch. from adit)	ditto ..	..	abt. 9′	0·3	19·2	65·3	15·2	..	12,636	13·1	..	ditto ..	—/12/1927
State Colliery	ditto ..	Fine coal (duff)	From run of mine coal	1·1	18·8	65·9	14·2	..	12,908	13·4	..	J. H. Reid ..	—/5/1928

* *Lbs. of water evaporated by 1 lb. of coal at and from 212° F.* † *Samples included all bands in seam.* ‡ *Not analysed—stated to be inferior.*

Face p. 32.]

The coal from the Bowen Seam is a fairly hard bituminous coal, with light emission of smoke on burning, and the analyses indicate a reasonably low sulphur content. Probably the whole output of the field will be won from this seam in the near future for many years to come. It is indicated by laboratory tests to be a good coking coal, but no practical tests in ovens have yet been carried out to determine whether it would make a good metallurgical coke.* The ash percentage is, however, high for making a first-class coke.

The ash in the coal produced from this seam at the State Colliery appears on visual examination to be largely inherent ash, and probably it will not wash successfully.

Coking and Coal-washing Tests.

Laboratory coking tests on 50-lb. parcels of coal from the Garrick and Bowen Seams were carried out by the Koppers Company, Pittsburg, Pa., U.S.A., in 1922, at the instance of the Minister for Mines, the Hon. A. J. Jones. These tests show proximate analyses as well as amount and composition of by-products obtained in coking. They also show that both coals coked well under laboratory conditions. This report was published in the "Queensland Government Mining Journal," July 1922.

It appears from office records that the manager of the Bowen State Colliery (Mr. Jas. Conway) manufactured on the field about 38 tons of coke from the Bowen Seam in a single beehive oven. A sample between 2 cwt. and 3 cwt. was forwarded to the Government Analyst in September 1925, and his certificate shows that it contained 18·8 per cent. ash. A shipment of 14 tons was sent to the general manager, Chillagoe Smelters, for analyses and practical test. The ash content was 18·7 per cent., and Mr. P. L. Goddard stated the hardness and density of the coke was excellent and the size very favourable for smelting.

It seems well established by this practical test (which would certainly not reach ideal conditions of coking), in addition to numerous laboratory tests, that the Bowen Seam provides a coal of excellent coking qualities. From its composition it can be expected to average about 78 per cent. coke from the original coal. Its one drawback apparently is the high percentage of ash.

In 1926 a sample of 50 lb. of run-of-mine coal was received from the manager of the State Colliery for examination and test as to its adaptability for washing. Visual examination showed that there was very little if any material that could be classed as free shale or stone in the coal. Recently a specific gravity analysis was made of a sample of this coal, consisting of the

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* See lower paragraph written later.

separation of coal particles of different densities through a series of liquids ranging from 1·30 sp. gr. to 1·58 sp. gr. The separation of the material was carried out by Mr. T. McCall, Senior Analyst, Government Analyst's Office, and the author; and the weighing of the fractions and their ash determinations were done by Mr. McCall. Tables showing the results obtained have been calculated by the author and are attached hereto for reference.

The system of specific gravity analysis is universally used for ascertaining the amenability of coals to commercial washery processes as well as for control tests of washing plants.

The run-of-mine coal as tested analysed 13·5 per cent. ash, which is probably a little on the low side. The two analyses from the State Colliery, published in the table in this report, show an average of 14·7 per cent. ash.

The tests indicate some principal features as follows:—

(1) There is very little "pure" coal; that which floats under 1·35 sp. gr. and contains 4·8 per cent. ash amounts to only 19 per cent. of the total. The "middlings" or those fractions floating over 1·35 and under 1·58 are high and total 75·54 per cent. of the coal treated. Good washing coals show large fractions floating under 1·35 and small amounts of "middlings."

(2) The fractions show a general dissemination of ash through the coal as intrinsic or constitutional ash, and as such it cannot be separated even by fine crushing and washing.

(3) The end residue is not clean stone, but hard carbonaceous shale and stony coal which will almost wholly float between 1·70 and 1·75 sp. gr. There is not, therefore, sufficient difference between the specific gravities of the bulk of the lighter fractions and the end residue of high ash coal and carbonaceous shale to ensure a clean separation in a washing plant.

(4) To obtain a reduction of ash from 13·7 per cent. to 10 per cent. in the coal treated, the attached tables show it would be necessary to discard approximately 26 per cent. of the coal as mined, under the conditions in which the specific gravity analysis was made. These are almost ideal and would not be obtained in a washing plant—hence a greater discard would be necessary in a washing plant for a similar result. Such a figure—probably 30 per cent.—would be too great a loss to ensure a reduction of only about 4 per cent. ash.

Taking run-of-mine Bowen coal as producing coke averaging 18·5 per cent. ash, the following New South Wales cokes* are tabulated with their ash contents for comparison:—

	Ash in Coke.
Hoskins Coke Works	18·5
Mount Lyell	15·95
Federal (from duff)	14·08
Mount Pleasant	15·19
" "	14·35
Corrimal-Balgownie	15·25
" "	15·85
Bellambi	15·99
Bulli	17·64
North Bulli	17·23
South Clifton	15·30
Illawarra Coke Company	15·05
Wallsend Purified Coal and Coke Company ..	13·34
" " " "	12·15

The above table shows that most of the coke is produced carrying between 14 and 16 per cent. ash, and if Bowen coke can be kept below 18 per cent. it has not much fear from the competition of New South Wales cokes in North Queensland, on account of its excellent physical qualities and the less freight it would be subject to. Most of the above cokes are manufactured from raw coals which are considerably higher than Bowen coal in ash, but they are amenable to washing.

Opinions have been expressed that the ash percentage could be considerably reduced by washing Bowen slack. Desirable as this would be, the specific gravity analysis of the run-of-mine coal holds out no hope for it.

Slack coal, according to analyses of average samples taken at different periods, contained 12·4 and 13·4 per cent. ash, being less than the run-of-mine coal at those periods.

It is probable that the stony coal, with relatively high ash, does not break up but remains with the screened coal. In that case the slack may always be lower in ash. It is a point that could be tested by a series of analyses of the slack. The first sample of slack taken by the writer analysed:

Moisture	1·0	
Volatile hydrocarbons	21·0	
Fixed carbon	65·6	= 78 per cent. coke.
Ash	12·4	

Slack of this composition should give a coke of about 16 per cent. ash.

The object of these tests might be epitomised as follows:—

> "Coal from the Bowen Seam producing, as it does, coke of excellent physical quality despite a high ash content (18-19 per cent.), are there any methods of obtaining a reasonably low-ash coke (e.g., about 15 per cent.) from it, should the demand for it arise?"

* Taken from "Coke," by L. F. Harper, Bull. 12, N.S.W. Geol. Sur., 1924.

The following conclusions are submitted for consideration :—

Conclusions.

(1) The coal at present being produced in the State Colliery, Collinsville, from the Bowen Seam does not appear amenable to washing on a commercial scale with a view to ash reduction in the manufacture of coke.

(2) The small coal and slack obtained from screening is probably a little lower in ash than the round coal, and this probability should be tested by a series of analyses of samples over a period of, say, several months. This would provide data for determining the approximate percentage of ash in coke produced from it.

(3) Experiments in screening the coal a little finer may reveal a slight reduction in ash in the slack. Therefore, screening tests with varying sized screens over a period of time and checked by ash determinations of samples would probably provide useful data as to quantities of lower-ash "fines" which could be made available for coking.

(4) The seam in certain areas may be a little lower in ash than the general average. This could be tested by sampling, and if substantiated coal from these areas, if considered advisable, reserved for coking with a view of keeping the ash in coke lower than 18 per cent. to 19 per cent.

SPECIFIC GRAVITY ANALYSIS, RUN-OF-MINE COAL, BOWEN SEAM, STATE COLLIERY, COLLINSVILLE.

Coal Yielded 13·5 Per Cent. Ash.

SIEVING ANALYSES.

$\frac{1}{2}''$ to $\frac{1}{4}''$	41 per cent.
$\frac{1}{4}''$ to $\frac{1}{8}''$	26 ,,
$\frac{1}{8}''$ to $\frac{1}{16}''$	13 ,,
$\frac{1}{16}''$ to 0″	20 ,,
	100

Table 1.

	Size $\frac{1}{2}''$ to $\frac{1}{4}''$ (41% of Sample).			
	Fractional.		Cumulative.	
	% *Weight.*	% *Ash.*	% *Weight.*	% *Ash.*
Floated on 1·30	0·75	2·1	0·75	2·1
,, ,, 1·35	8·45	4·9	9·20	4·67
,, ,, 1·40	30·30	9·8	39·50	8·60
,, ,, 1·45	33·70	13·7	73·20	10·96
,, ,, 1·50	14·90	19·3	88·10	12·25
,, ,, 1·55	4·80	23·6	92·90	12·94
,, ,, 1·58	1·45	29·3	94·35	13·19
Sinks 1·58	5·05	44·8	100·00	14·71

SUMMARY.

		% *Weight.*	% *Ash.*
"*Pure Coal*" ..	Lower than 1·35	9·20	(4·67)
"*Middlings*" ..	1·35 to 1·58 ..	85·15	(14·1)
"*Dirt*"	Higher than 1·58	5·05	(44·8)

Table 2.

	Size $\frac{1}{4}$" to $\frac{1}{8}$" (26% of Sample).			
	Fractional.		Cumulative.	
	% *Weight.*	% *Ash.*	% *Weight.*	% *Ash.*
Floated on 1·30	3·85	3·1	3·85	3·1
,, ,, 1·35	9·75	5·4	13·60	4·76
,, ,, 1·40	26·80	9·5	40·4	7·90
,, ,, 1·45	29·00	13·3	69·4	10·16
,, ,, 1·50	18·40	18·5	87·8	11·90
,, ,, 1·55	5·15	22·6	92·9	12·50
,, ,, 1·58	1·20	26·7	94·35	12·64
Sinks 1·58	5·50	43·7	100·00	14·34

SUMMARY.

		% *Weight.*	% *Ash.*
"*Pure Coal*" ..	Lower than 1·35	13·60	(4·76)
"*Middlings*" ..	1·35 to 1·58 ..	80·75	(13·8)
"*Dirt*"	Higher than 1·58	5·50	(43·7)

Table 3.

	Size $\frac{1}{8}$" to $\frac{1}{16}$" (13% of Sample).			
	Fractional.		Cumulative.	
	% *Weight.*	% *Ash.*	% *Weight.*	% *Ash.*
Floated on 1·30	7·45	2·8	7·45	2·8
,, ,, 1·35	16·10	5·5	23·55	4·64
,, ,, 1·40	24·50	8·9	48·05	6·73
,, ,, 1·45	26·80	13·0	74·85	8·97
,, ,, 1·50	12·65	18·6	87·50	10·37
,, ,, 1·55	5·05	23·3	92·55	11·07
,, ,, 1·58	1·45	27·8	94·00	11·33
Sinks 1·58	5·50	43·5	100·00	13·04

SUMMARY.

		% *Weight.*	% *Ash.*
"*Pure Coal*" ..	Lower than 1·35	23·55	(4·64)
"*Middlings*" ..	1·35 to 1·58 ..	70·45	(13·4)
"*Dirt*"	Higher than 1·58	5·50	(43·5)

Table 4.

——	Size $\frac{1}{16}$″ to 0 (20% of Sample).			
	Fractional.		Cumulative.	
	% *Weight.*	% *Ash.*	% *Weight.*	% *Ash.*
Floated on 1·30	33·50	4·4	33·50	4·4
„ „ 1·35	8·05	7·2	41·55	4·94
„ „ 1·40	21·20	8·6	62·75	6·18
„ „ 1·45	17·50	17·8	80·25	8·71
„ „ 1·50	9·95	18·8	90·20	9·81
„ „ 1·55	3·70	23·6	93·90	10·37
„ „ 1·58	1·15	30·0	95·05	10·60
Sinks 1·58	4·65	44·0	100·00	12·12

Summary.

		% *Weight.*	% *Ash.*
"*Pure Coal*" ..	Lower than 1·35	41·55	(4·94)
"*Middlings*" ..	1·35 to 1·58 ..	53·5	(15·0)
"*Dirt*"	Higher than 1·58	4·65	(44·0)

Table of Summaries.

——	$\frac{1}{2}$″ to $\frac{1}{4}$″ 41%	$\frac{1}{4}$″ to $\frac{1}{8}$″ (26%)	$\frac{1}{8}$″ to $\frac{1}{16}$″ (13%)	$\frac{1}{16}$″ to 0 (20%)
	Ash.	*Ash.*	*Ash.*	*Ash.*
Lower than 1·35 ..	9·20 (4·67)	13·60 (4·76)	23·55 (4·64)	41·55 (4·94)
1·35—1·58	85·15 (14·1)	80·75 (13·8)	70·45 (13·4)	53·5 (15·0)
Higher than 1·58 ..	5·05 (44·8)	5·50 (43·7)	5·50 (43·5)	4·65 (44·0)

Summary of Whole Sample.

		% *Weight.*	% *Ash.*
"*Pure Coal*" ..	Lower than 1·35	18·68	4·8
"*Middlings*" ..	1·35 to 1·58 ..	75·71	14·0
"*Dirt*"	Higher than 1·58	5·14	44·3

Remarks on Above Tables.

The percentage of ash in total sample of coal by calculation from fractions in table = 13·87 per cent.; by analysis 13·5 per cent. ash. The sizing of the coal shows that the quality of coal improves progressively from coarse to fine. The "pure coal" fractions—i.e., coal floating on and under 1·35 solution—increase in amount progressively with the degree of fineness as follows:—Size, $\frac{1}{2}$ in.-$\frac{1}{4}$ in., 9·20 per cent.; size, $\frac{1}{4}$ in.-$\frac{1}{8}$ in., 13·60 per cent.; size, $\frac{1}{8}$ in.-$\frac{1}{16}$ in., 23·55 per cent.; size, $\frac{1}{16}$ in.-0, 41·55 per cent. This is reflected in the ash contents of the sizes, which are progressively 14·71 per cent., 14·34 per cent., 13·04 per cent., 12·12 per cent.

Tables Showing Cumulative "Floatings" and "Sinkings."

Table 5.

Specific Gravity Solution.	Size ½" to ¼". *Ash 14·7 %.*			
	Float.		Sink.	
	% Weight.	*% Ash.*	*% Weight.*	*% Ash.*
1·30	0·75	2·1	99·25	14·8
1·35	9·20	4·67	90·80	15·7
1·40	39·50	8·60	60·50	17·0
1·45	73·20	10·96	26·80	24·9
1·50	88·10	12·25	11·9	32·8
1·55	92·90	12·94	7·1	37·7
1·58	94·35	13·19	5·05	44·8

Table 6.

Specific Gravity Solution.	Size ¼" to ⅛". *Ash 14·3 %.*			
	Float.		Sink.	
	% Weight.	*% Ash.*	*% Weight.*	*% Ash.*
1·30	3·85	3·1	96·15	14·5
1·35	13·6	4·76	86·4	15·8
1·40	40·5	7·9	59·6	18·6
1·45	69·4	10·16	30·6	23·6
1·50	87·8	11·9	12·2	31·6
1·55	92·9	12·5	7·1	37·8
1·58	94·3	12·64	5·5	43·7

Table 7.

Specific Gravity Solution.	Size ⅛" to 1/16". *Ash 13·0 %.*			
	Float.		Sink.	
	% Weight.	*% Ash.*	*% Weight.*	*% Ash.*
1·30	7·45	2·8	92·55	13·8
1·35	23·55	4·6	76·45	15·6
1·40	48·05	6·7	51·95	16·9
1·45	74·85	9·0	25·15	24·9
1·50	87·50	10·4	12·5	31·2
1·55	92·55	11·1	7·45	36·7
1·58	94·00	11·3	5·50	43·5

Table 8.

Specific Gravity Solution.	Size $\frac{1}{16}$" to 0. *Ash 12·1 %.*			
	Float.		Sink.	
	% Weight.	*% Ash.*	*% Weight.*	*% Ash.*
1·30	33·50	4·4	66·5	15·9
1·35	41·55	4·9	58·45	17·0
1·40	62·75	6·2	37·25	22·0
1·45	80·25	8·7	19·75	25·9
1·50	90·20	9·8	9·8	33·2
1·55	93·90	10·4	6·1	38·2
1·58	95·05	10·6	4·65	44·0

Summary of Tables 5–8.

Specific Gravity Solution.	Size $\frac{1}{2}$" to 0. *Ash 13·5 %.*			
	Float.		Sink.	
	% Weight.	*% Ash.*	*% Weight.*	*% Ash.*
1·30	8·97	4·00	91·03	14·7
1·35	18·68	4·77	81·52	15·9
1·40	45·49	7·51	54·51	18·1
1·45	73·83	10·01	26·17	24·7
1·50	88·36	11·42	11·64	32·3
1·55	93·05	12·07	6·95	37·6
1·58	94·43	12·28	5·14	44·1

THE UPPER BOWEN COAL MEASURES.

The Upper Bowen Formation is estimated to be over 9,000 ft. thick, and consists, as far as known, wholly of freshwater sediments, with the exception of one marine horizon localised, as yet, to one district (Havilah). The extent and importance of the coal seams in these measures are unknown, for they cover probably 800 square miles of gently undulating to plain country, much of it covered by rich black soil and thickets of brigalow scrub. Dr. Jack examined portion of the area occupied by the Upper Bowen Coal Measures, particularly around Havilah and Jack's Creek, and details of several coal occurrences are given in his report. Beyond this and the reconnaisance survey recently carried out, no other geological work has been done. Apparently no coal prospecting work has ever been accomplished beyond that carried out in the vicinity of the Bowen River, between Havilah and Jack's Creek, by a party of prospectors sent out in 1875-1876 by the Bowen River Coal Association in charge of Mr. A. Macarthur, and a Government bore sunk to a depth of

340 ft. near Havilah Station by the driller, Mr. S. L. Hester, in the year 1886. Jack had recommended several bores in this locality as a means of testing the field. The Havilah bore was put down 340 ft. in the Upper Bowen Coal Measures, but they were found to be intensely intruded, and the bore was completed at the depth mentioned, and the boring plant dismantled. As a test of portion of the Upper Coal Measures, it was practically negligible, owing to the effect of the local intrusions on the coal. The following record of the bore is compiled from "Boring Operations at Coalfield, Bowen"*:—

HAVILAH COAL BORE.

Ft.	in.		Ft.	in.	
Surface		to	35	0	—Yellowish sandstone
35	0	to	69	0	—Soft grey sandstone
69	0	to	71	0	—Blue shale
71	0	to	75	0	—Coarse grit sandstone
75	0	to	81	6	—"*Burnt*" *coal*†
81	6	to	87	6	—Intrusive rock†
87	6	to	94	6	—"*Burnt*" *coal*†
94	6	to	99	0	—Blue shale
99	0	to	136	0	—Sandstone
136	0	to	143	0	—Blue shale
143	0	to	240	0	—Greenish sandstone
240	0	to	302	0	—(?)
302	0	to	310	0	—Green and grey porphyry
310	0	to	340	0	—Green and grey porphyry, with innumerable *coal* seams.

The available information is thus practically confined to observations by Jack and the present writer. The following is a résumé, compiled for this report, of the occurrences noted by Jack in his report on the Bowen River Coalfield (pp. 24-27):—

Macarthur Seam.—This occurs on the south side of the Bowen River near the mouth of Jack's Creek. It contains 3 ft. 2 in. of coal, divided by 4 inches of sandstone with dolerite overlying the seam. This is referred to as a 10-ft. seam by the original prospector, A. Macarthur. (Appendix B, Jack's Report.) The site of a 5-ft. seam is recorded in Jack's Creek, near Bowen River, but the coal was not seen by Jack. It is considered by him to be the Macarthur Seam.

Daintree Seam.—This outcrops in the bed of the Bowen River, a quarter of a mile below Rosella Creek. Seam shown as 17 ft. 5 in. thick, containing 13 ft. 7 in. coal badly banded, except for a section of 7 ft. of brownish-black laminated coal of fair quality. Seam is overlain by 25 ft. of dolerite.

Analysis of 7-ft. seam (after Jack).

	Top of Seam. Per cent.	Bottom of Seam. Per cent.
Water	2·44	2·50
Volatile hydrocarbons	15·72	13·09
Fixed carbons	57·40	57·14
Ash	24·44	27·27
	100·00	100·00

Havilah Seam.—This outcrops in the bank of Rosella Creek where Havilah paddock fence crosses creek. The seam consists of 10 ft. 6 in. of coal burnt by "white trap" intruded along bedding.

* Parliamentary Paper, Brisbane, 24th November, 1886.

† Apparently the Havilah Seam described by R. L. Jack.—J.H.R.

The occurrence of coal has been reported by Cameron* in a well at a depth of 60 ft. at Byerwin Homestead. It does not appear to occur in a seam of workable thickness, but the analysis of a sample taken from the coal lying at the surface indicated a satisfactory quality.

The following information is confined to surface exposures of coal observed during the recent fieldwork, and merely increases the area of the Upper Bowen Coal Measures, over which coal has been observed to occur, as well as increasing the known number of horizons on which it occurs.

Blenheim Creek.—1 ft. of "burnt" coal, north bank of creek, $1\frac{3}{4}$ mile (?) above junction of Bowen River.

Coal Gully.—This is a small gully crossed by the Collinsville road, about 4 miles north-west of Blenheim Homestead. Two weathered outcrops of coal observed near road crossing, respectively 4 to 5 ft. and 1 ft. thick, angle of dip 30° to the south-west.

Dingo Bend.—This locality is about 1 mile north of Coal Gully. Coaly shales were observed outcropping about $\frac{1}{2}$ mile east of the road, angle of dip 25° to the south-west.

Sandy Creek.—This creek rises in the Redcliffe Range, and flows north-easterly, entering the Bowen River about 8 miles from Blenheim Homestead. About 2 miles above the junction with the river, two outcrops of distinct seams occur in the creek banks, each showing about 2 ft. of coal, though the thickness of either seam could be much more. They dip to the south-west at about 15°, and one is lying a few feet under an andesite (?) sill. The horizon of these seams is probably about 4,000 ft. above that of the seams exposed at Coal Gully, near Blenheim.

Stoney Creek.—Mount Coolon road crossing, 12 miles south of Havilah. A small crop of coaly shales occurs in a branch gully of this creek, dip angle 30° to the north-west.

The following two occurrences are across the divide of the Leichhardt Range, and outside the Bowen River watershed, but are quoted as showing the continuation of coal seams in the Upper Bowen Coal Measures, which continue uninterruptedly to the south, thus far at least.

Mount Hillalong Station.—Mr. W. Richards of this station informed me that a bore put down 150 ft. on Suttor Creek east of the homestead passed through several small coal seams between 110 ft. and 150 ft.

Suttor Creek Homestead.—A shaft sunk on Suttor Creek, 4 miles south-west of the homestead, passed through 4 ft. of coal at 60 ft.

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* W. E. Cameron. Additions to Geology of the Mackay and Bowen Districts. Q.G S. Pub. 181, Brisbane, 1902.

The information regarding coal in the Upper Bowen Formation must be regarded as being very incomplete. As the area becomes settled, it is probable many more outcrops will be discovered. Coal seams, however, appear to have a wide distribution, and to be on a number of distinct horizons. The coal so far as tested by proximate analysis is a bituminous one, and the few analyses quoted by Jack indicate a close approximation in composition to that of the seams of the Collinsville Measures.

Character of Coal.

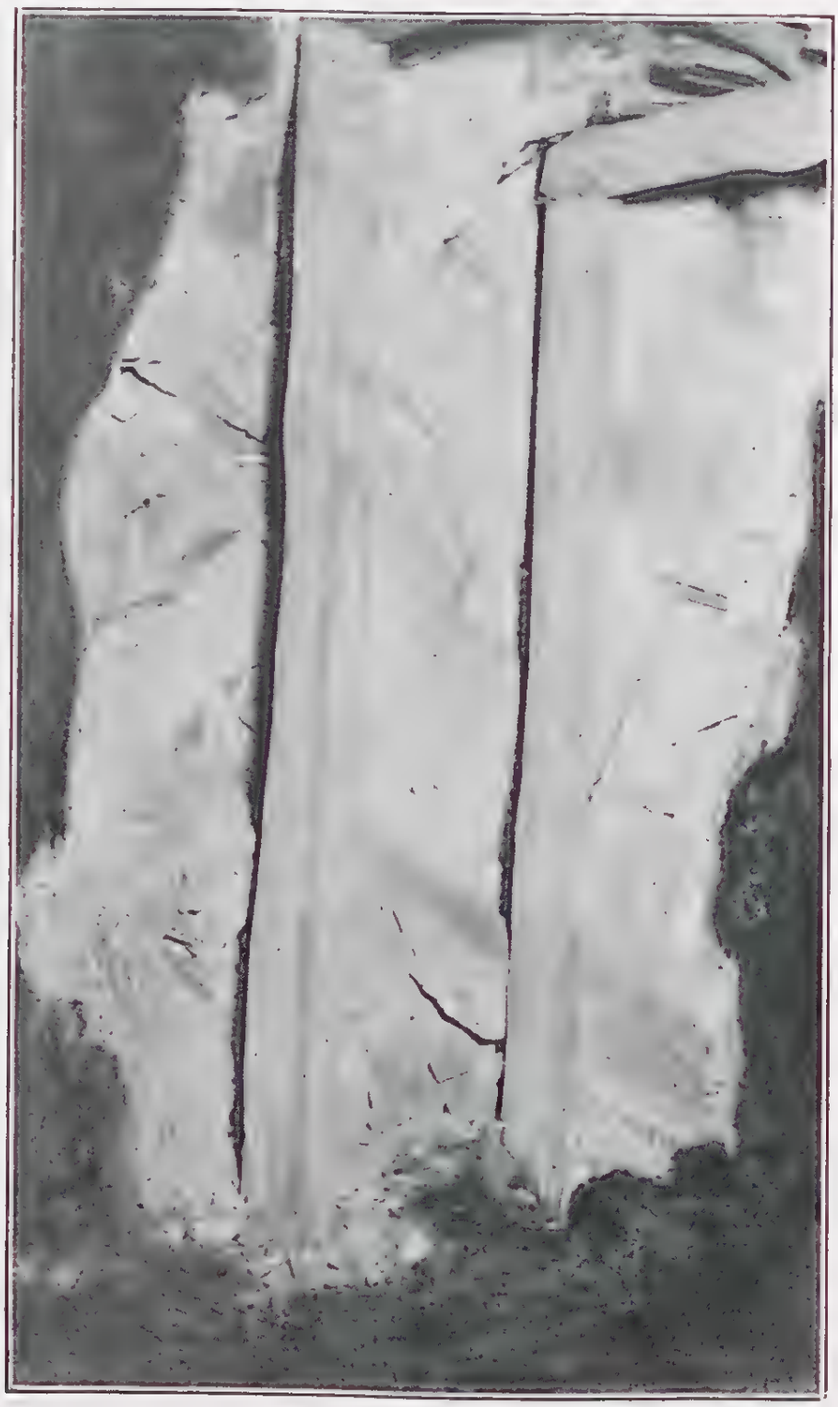
The coals of the Upper Bowen Formation have not yet been exploited, and it cannot be said at present that we have any precise knowledge of the number, size, and quality of the seams. We know that coal does occur in many localities, and on many different horizons. Only two analyses of any value are available. These are of coal samples obtained from a 7-ft. section of the Daintree Seam, near Havilah, collected by Dr. Jack, and from a seam at Byerwin, collected by Mr. Cameron. The horizon of the Daintree Seam is certainly very low down in the Upper Bowen Formation, and the Byerwin Seam is considered to be very high up in it. Both are bituminous coals with the following compositions, less ash and moisture:—

Upper Bowen Coals.	Volatile Hydro-carbons.	Fixed Carbon.	Fuel Ratio.
Daintree Seam, Havilah	20·1	79·9	3·8
Byerwin Seam	26·9	73·1	2·7

On the Bowen River Field it therefore appears likely that the coals in the Middle and Upper Bowen Formations will ultimately be found not to differ very greatly in composition when more comprehensive information regarding the latter is available. The Upper Bowen Formation close to the south of this field contains coal with much less volatile matter according to Jack. Thus the Bee Creek coal and the Walker's Creek coal, respectively 15 and 30 miles south of the Bowen River Field, are semi-bituminous and semi-anthracitic coals, with the following composition, less ash and moisture (after Jack):—

Upper Bowen Coals.	Volatile Hydro-carbons.	Fixed Carbon.	Fuel Ratio.
Bee Creek	17·2	82·8	4·8
Walker's Creek	9·3	90·7	9·8

Jack stated regarding the above*: "The coal of Walker's Creek is an anthracite containing a higher percentage of fixed carbon and a lower percentage of earthly impurities than any



[*Photo., J. Conway.*

Fig. 19.—Decomposed Igneous Dyke Cutting the Bowen Seam in No. 1 West Main Level, State Colliery.

coal of its class known in Queensland or New South Wales." They are stated to occur in very gently dipping strata in a district apparently free from intrusive rocks.

The fact that the Upper Bowen Formation contains coals of a less volatile type than the Collinsville or Middle Bowen

* R. L. Jack. *Op. cit.*, p. 168.

Formation finds a parallel in the Hunter River coal-bearing basin, where the Lower or Greta coals (Fuel Ratio 1·3) are higher in volatile matter than the Newcastle (F.R. 1·7) and Bulli (F.R. 2·8) coals of the Upper Coal Measures.

EFFECTS OF INTRUSIVE ROCKS.

The Middle and Upper Coal Measures are known to be extensively intruded from both drilling records and surface observations. These appear to be almost always sills, some of them of very great thickness—e.g., the Brisbane-Bowen Coal Company in their No. 1 bore passed through one 60 ft. thick. From surface observations it is impossible to conjecture the extent of the damage done to the coal seams since seams have been found by boring to be affected and to contain dolerite, &c., where no outcrops of intrusive rocks occur within reasonable distance at the surface. A very large area of the entire coalfield has been found to be either extensively or moderately intruded by igneous rocks and it is certain, therefore, that very large quantities of coal have been rendered unfit for mining. Blenheim, Havilah, the Bowen River in the vicinity of Jack's Creek, the district a few miles to the west of Collinsville, are each localities where evidence of igneous intrusion through the sedimentary rocks is particularly well displayed. Jack shows several sections of outcrops of intruded coal seams as well as making frequent references to the subject, one of which is (*op. cit.* page 7) ". . . molten rocks of the dolerite type were again and again injected along lines of weakness in the sedimentary rocks."

The diamond drilling in the Collinsville district has provided data for estimating more approximately the damage to the seams in that particular area. The whole of the six seams have suffered to a different extent, but in a marked degree. As an instance, the Scott Seam in a total of 20 bores was found to be totally destroyed in 6, partially destroyed or affected in 4, and free from visible effects of intrusion in 10. In the Bowen Seam, in 19 bores, the figures were respectively 2, 2, and 15, but as the bores are not spaced at equal intervals these figures do not reveal any idea of the area, and consequently the tonnage, of coal destroyed or affected. In an area of 20 square miles at Collinsville, in which the coal reserves have been estimated, the records of five different bores point to the probability of the Bowen Seam being so affected over the western half of that area as to be considered unworkable there. Leaving out of consideration the Blake Seam, owing to incompleteness of boring data, the estimated total tonnage in this area in the Garrick, Scott, Denison, Potts, and Bowen Seams reaches 332,060,000 tons. Of this the probable workable tonnage, based on the thickness of each seam and the area in which each is considered likely to be free from intrusive effects in the light of the available bore records, is approximately estimated to be only 141,720,000. The balance of 190,340,000 is thought likely to be a rough approximation to the

amount of coal rendered more or less unworkable in this area. Since the occurrence of the intrusive rocks is capricious, the boundaries of affected areas in any seam cannot be defined closely without considerably more boring data over the western half of the area. Therefore, these figures can only be accepted tentatively, and are submitted only to give some idea of what serious tonnages of coal have probably been rendered unfit for mining.

ESTIMATE (APPROXIMATE) OF PROBABLE TONNAGE OF COAL AFFECTED BY INTRUSION.

(*Approximate area 20 square miles at Collinsville.*)

Seam.	Total Tonnage.	Tonnage Likely to be Unaffected.	Tonnage Probably Rendered Unworkable by Intrusions.
Garrick	48,300,000	17,100,000	31,200,000
Scott	67,460,000	26,550,000	40,910,000
Denison	62,560,000	28,680,000	33,880,000
Potts	17,040,000	8,250,000	8,790,000
Bowen	136,700,000	61,140,000	75,560,000
Totals	332,060,000	141,720,000	190,340,000

No large portion of the area under consideration here is apparently entirely free from intrusion. For instance, the Garrick and Bowen Seams appear to have almost complete immunity in the Bowen Consolidated leases and the State Reserve

Fig. 20.—TWO INTRUSIVE SILLS IN UPPER BOWEN SANDSTONES, BOWEN RIVER, NEAR SANDY CREEK, BLENHEIM.

No. 1,* while the Scott and Denison Seams are very much intruded there. In the western half, embracing State Reserves Nos. 2 and 3 and portion of M.L. 46, the Garrick and Bowen have been almost completely destroyed, while the Scott and Denison have not been affected in Bores 24 and 26 on the No. 2 State Area.

The only coal bore put down through the Upper Coal Measures, that at Havilah, passed through two sills in a depth of 340 ft.; in each case they were associated with coal seams.

Surface evidence of intrusions is almost general over the entire field, but this evidence diminishes south of Blenheim and Byerwin, and probably the coal beds there are not seriously affected. It is not known yet whether the important Middle Bowen Coal Measures exist there, but it is probable that they do so.

With the exception of the extreme southern portion of the field it is to be expected that only limited areas will be located here and there where seams are entirely free from the destroying influence of the intrusive rocks. Their presence will add much to the expense of prospecting the field by drilling, particularly at the greater depths. The thickness of the Bowen Seam, however, means large tonnages in comparatively small areas which may be found to be unaffected.

* Recently, however, two decomposed igneous dykes were found cutting the Bowen Seam in the State Colliery at a depth of 100 ft., although there is no surface evidence of them.—J.H.R.

GEOLOGY OF THE COALFIELD.

Considerable detail is now known of the Marine Series and the important Collinsville Coal Measures immediately underlying them, which together form the Middle Bowen Formation. The stratigraphical detail of the Lower and Upper Bowen Formations is still very incomplete. Jack's classification of the series into the Upper, Middle, and Lower Bowen Formations is followed in this report with some slight modifications as to their subdivisions. These are (1) the inclusion of his bedded porphyrites and volcanic agglomerates in the Lower Bowen, and (2) the differentiation of the Middle Coal Measures from the Marine Series. These are of minor importance, and it can be stated that Jack's classification made forty-five years ago still holds place. His correlation of the Bowen Formations with the Permo-Carboniferous System of New South Wales (page 36) cannot, however, be entirely followed in the light of all evidence now available. For instance, the bedded traps and Lower Sandstones of the Bowen River, which he first compared with *Lepidodendron* beds of New South Wales, have now for the first time yielded specimens of *Glossopteris*, and the differentiation of the Collinsville Coal Measures from the Middle Bowen Marine Series permits more precise correlation with the Lower Coal Measures and the Upper Marine Series of New South Wales, respectively, than he was able to formulate at that time.

Jensen's views on the correlation of the Bowen River Formations are radically opposed to those of Jack. He states,* *inter alia*, ". . . and show that this Marine Series (*Middle-Bowen of Jack, J.H.R.*) is Upper Kuttung or Lower Uralian, and that the Bowen (Collinsville) Coal is a Carboniferous coal lower than the Greta coal of New South Wales." Thus, on this statement, the series that Jack considered was partly equal to the Upper Marine of New South Wales is relegated to a very much lower position in the geological scale. This alteration is not supported either by the evidence obtained from the field itself or by that from the Permo-Carboniferous Formations in adjacent districts. It will be shown hereafter that *Glossopteris* and Permo-Carboniferous Marine fossils (in extra-Bowen areas), also still lower coals, occur on various horizons in the Lower Bowen volcanics which underlie the Collinsville coals, and are, therefore, in stratigraphical position some thousands of feet below the beds that Jensen states are Upper Kuttung or Lower Uralian.

SEQUENCE AND CLASSIFICATION.

(*See Fig.* 22.)

Beginning at the basement of the Permo-Carboniferous sedimentary rocks is the Lower Bowen Formation, of a thickness of

* H. I. Jensen. Some Notes on the Permo-Carboniferous and overlying systems in Central Queensland. Proc. Linnean Soc. N.S.W., vol. xviii., pt. 2, p. 156.

at least 5,500 ft. at Collinsville, mainly consisting of fragmental volcanic rocks and lavas, but with many thin beds of interbedded sandstone, and including also a thickness of coal measures (as one group) of approximately 400 ft. The upper limit of this formation at Collinsville is an important rhyolitic horizon (tuffs, &c.), sometimes overlain with a thin sheet of andesite, immediately on which lie the basal conglomerates and sandstones of the Middle Bowen Formation. This consists of 700 ft. of coal measures overlain by the Marine Series, of a thickness of 2,400 ft. in the northern portion of the coalfield, which contains a most abundant marine fauna. This series appears to be entirely of marine deposition, and is the only Marine Series developed on the Bowen River Coalfield. Resting on the marine beds is a Freshwater Series, approximately up to 9,600 ft. thick, with a number of coal measures interbedded in a great thickness of tuffaceous sandstones, &c. The marine horizon noted by Jack near Havilah occurs in this formation, and is the only one present in it as far as known. The sequence of Permo-Carboniferous strata in descending order is—

UPPER BOWEN	Freshwater Series .. .. .. With undifferentiated coal measures, including those of Havilah, Blenheim, Jack's Creek, Byerwin, &c..	9,600 ft.
MIDDLE BOWEN	Marine Series	2,400 ft.
	Collinsville Coal Measures	700 ft.
LOWER BOWEN	Mount Devlin Volcanic Series	2,000 ft.
	Mount Devlin Coal Measures ..	400 ft.
	Mount Toussaint Volcanic Series ..	3,000 ft. (?)

GEOLOGICAL STRUCTURE.

The main structure of the coalfield is a very asymmetrical syncline, converging at the northern end, and widening towards the south. The dips on the extreme eastern side are very steep, angles ranging from 40° to the vertical, averaging probably 50° to 55°, while the easterly dips on the west side average about 5° to 7°. The structure appears to be not at all complicated, except at the northern end, where severe compression of the beds has introduced overthrust faulting, minor synclines and anticlines and elbow bends in the strike lines. The landscape features in this area—Collinsville—are a clear expression of the local geological structure. The ridges just north of the township, running at right angles to one another, and then reverting to a parallel course, have limned with incisive clearness the deformations to which the coal seams and associated strata have been subjected in this corner of the field during the great compressive movement which operated from the oceanic side and formed the great Bowen River syncline. The structure of the Collinsville area is referred to in detail in the previous chapter.

Following the marine beds south from Collinsville, these are found to be vertical at several points as far as Jack's Creek. From

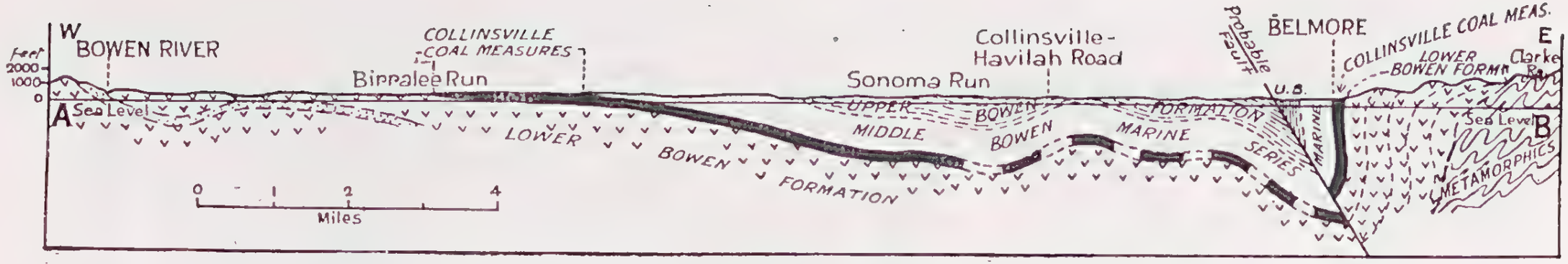


FIG. 21 (*a*).—GEOLOGICAL SKETCH SECTION ON LINE A–B, BOWEN RIVER COALFIELD MAP.

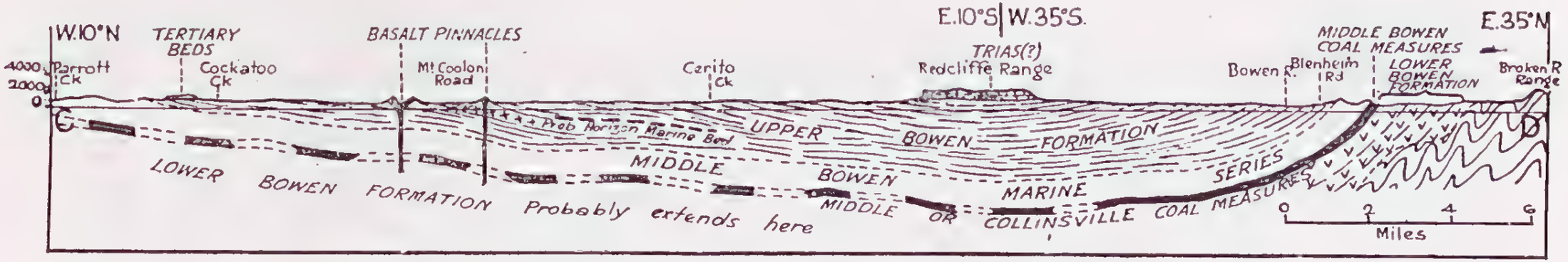


FIG. 21 (*b*).—GEOLOGICAL SKETCH SECTION ON LINE C–D, BOWEN RIVER COALFIELD MAP.

Basin Creek southwards, "The Wall" sandstone, which extends in outcrops at least as far as Blenheim, is a splendid key horizon. This horizon is wonderfully straight and disproves faulting, of any moment, oblique to the strike of the beds. There appears to be an ordered regularity of strike and dip practically all along the eastern side of the field south of Jack's Creek, the lower beds dipping very steeply (40° to 70°), and gradually flattening, without reverse dips, towards the synclinal axis. The single exception noted to this rule is near Blenheim Homestead. There are some vertical beds in Blenheim Creek, and several reverse dips. The extent of this disturbance is not known; no evidence of it was found in the other sections described in this report on the eastern side of the field. On the western side of the field the strata are inclined very gently, and are somewhat undulating, so that the occasional dips in any direction that occur are not unexpected. There is, of course, a general easterly inclination, despite areas of reverse dips of low angles, as, for instance, on the southern side of Rosella Creek crossing (Havilah).

BASEMENT ROCKS.

The coalfield is bounded on the north and east by the Clarke and Broken River Ranges, whose general altitudes are from 2,000 ft. to 3,000 ft. above sea-level, whereas the greater portion of the coalfield lies between 650 ft. and 1,100 ft. above that level. These higher ranges expose granite, quartz porphyry, diorite and metamorphic rocks, which form the basement rocks on which the Permo-Carboniferous sediments have been laid down. Granite and porphyry occur principally on the Clarke Range, and form a boundary with the Lower Bowen Formation near Pine Creek, about 5½ miles north of Collinsville. Jack shows the lowest volcanic beds resting on an uneven surface of granite. The age of the granite is not known, but no evidence has been found to disagree with Jack's conclusion that it is of pre-Lower Bowen age. At various points around Mount Devlin, where the Lower Bowen Rocks occur, small areas of rather coarse granite detritus occur amongst the volcanics. A conspicuous example occurs on the Bowen road, 2½ miles N.N.W. of the State Colliery. In none of these have outcrops of undecomposed rock been found. They are considered to be most likely due to the weathering of the higher elevations of an eroded granite surface reached by denudation.

The metamorphic rocks predominate along the eastern side of the field, and their separation from the Lower Bowen volcanics is often a difficult matter. Jack has stated that the strike of the former is usually N.W. to S.E., which is approximately that of the steeply folded eastern limb of the Permo-Carboniferous syncline. Therefore, as some of the Lower Bowen strata have an appearance of considerable age where highly folded, while the metamorphics have not yet yielded palæontological evidence of age, confusion easily arises where one is not dealing with clearly defined lithological types, as, for

example, crystalline schists or massive quartzites. Jack shows that schists, gneiss, &c., do occur, but the writer has only observed quartzites, slates, volcanics, &c., at the few points where observations in the older rocks have been made. Jack's observations are, perhaps, supported by the presence of schist erraties in the Permo-Carboniferous basin. Jack, Gibb Maitland, and Cameron, who have mapped in the Permo-Carboniferous basin at some portion or other of the eastern boundary north of the Mackenzie River, have apparently all experienced the same difficulty in separating Lower Bowen rocks from metamorphics. Jack has mapped in bedded rhyolite and andesite tuffs, &c., as metamorphics between Collinsville and the Emu Plains crossing of the Bowen River, which beyond doubt are of Lower Bowen age. Cameron* disagrees with Gibb Maitland on their differentiation in the area between Mount Britton and Nebo. From the writer's traverse across the ranges from Eungella to the Bowen field over the Mount Barker Range, it is considered very probable that much of the area previously mapped in as belonging to the "Metamorphic" group on the Queensland Geological Survey maps will ultimately prove to be Lower Bowen volcanics and sediments which have been highly folded and considerably altered. The schists and massive quartzites are separable on lithological grounds. The Mount Barker tableland, the western side of which forms part of the Broken River Range, is a complex of quartzite, diorite, and hornblende-porphyrite. As the range is partly descended to the coalfield, quartzite and slates have a strike of 320°, and dip south-west at angles of 40° to 70°, which conforms closely to the usual strike and dip of the very regularly disposed beds along the eastern side of the Permo-Carboniferous basin. On lithological grounds they have been mapped as belonging to the metamorphic group, but they may possibly be Lower Bowen or Carbonifeous rocks altered by an adjacent diorite intrusion.

Cameron† has stated that a distinct unconformity exists between the metamorphic group of Mount Britton and Eungella and the overlying marine Permo-Carboniferous beds. Along the eastern side of the Bowen field there is also evidence as follows of unconformity between quartzites and the Marine Series. On the Collinsville-Emu Plains road, about 1¼ mile south-east of its junction with the Havilah road, and near Basin Creek, a low ridge of quartzite projecting westerly interrupts the regular continuity of the marine beds. On the southern side of this ridge, the well-defined "Wall Sandstone" (basal marine) runs almost up to the quartzites. On the northern side it is absent, but not through faulting, since a 60-ft. thickness of the Strophalosia sandstone is showing in its anticipated position there. This is the Big Strophalosia horizon so well developed over a length of outcrop of at least 40 miles, and which on the

* W. E Cameron. Q.G.S. Pub. 200, p. 14.

† W. E. Cameron. *Op. cit.*, p. 14.

Bowen River, further south, is found 300 ft. above the top of the basal sandstones.

The basement rocks have not been mapped on the west side of the coalfield. They do not approach within many miles of the known coal-bearing portion of the field. The Lower Bowen Formation outcrops continuously for at least 18 miles on the west side of Collinsville, owing to its gentle dip and the undulations of the strata.

THE LOWER BOWEN FORMATION.

This formation, essentially consisting of lavas and fragmental volcanic rocks, has been extended so as to embrace the following divisions, in descending order, of Jack's classification (p. 4) :—

(*d*) Bedded porphyrites and basalts of Mount Toussaint* and Mount Macedon Ranges (= *Mount Devlin Volcanics*).

(*c*) Lower Series of coalfield (= *Mount Devlin Coal Measures*).

(*b*) Volcanic agglomerate (= *Mount Toussaint Volcanics*).

Jack confined the Lower Bowen Formation in the type district to the sandstones to the north of Mount Devlin, which he estimated to be 880 ft. thick, and extended them north-westerly in his map to connect with further sandstone beds traversed on the old Bowen-Sonoma road. This connection does not occur in a direct line as shown by him, as the mapping of the Mount Devlin measures shows them to turn sharply to the south around that mountain, instead of continuing to the north-west. It would also mean the pinching out, or overlap to the north-west, of the Mount Toussaint volcanics, which are probably 3,000 ft. thick north of Mount Devlin.

The three groups are united to comprise the Lower Bowen since, as shown by Jack, they are found to be conformably bedded, and since, apart from the Mount Devlin measures, sedimentary beds including both sandstones and tuffs are not uncommonly found interbedded throughout the greater mass of volcanics. The strata of the formation appear to represent deposition of fragmental volcanic material under aqueous conditions, intermingled with lava flows, and right through the period, at intervals, deposition of freshwater sandstones, &c., in intermissions of volcanic activity.

Mount Toussaint Volcanics.

The Mount Toussaint (or lower) volcanics are seen to extend along the west of the railway line from the 42-mile peg to the

* The position of Mount Toussaint on Dr. Jack's map of the Bowen Coalfield is in an incorrect position relative to Mount Devlin. Whereas it should be shown north-west of, it is shown nearly south-west of Mount Devlin.

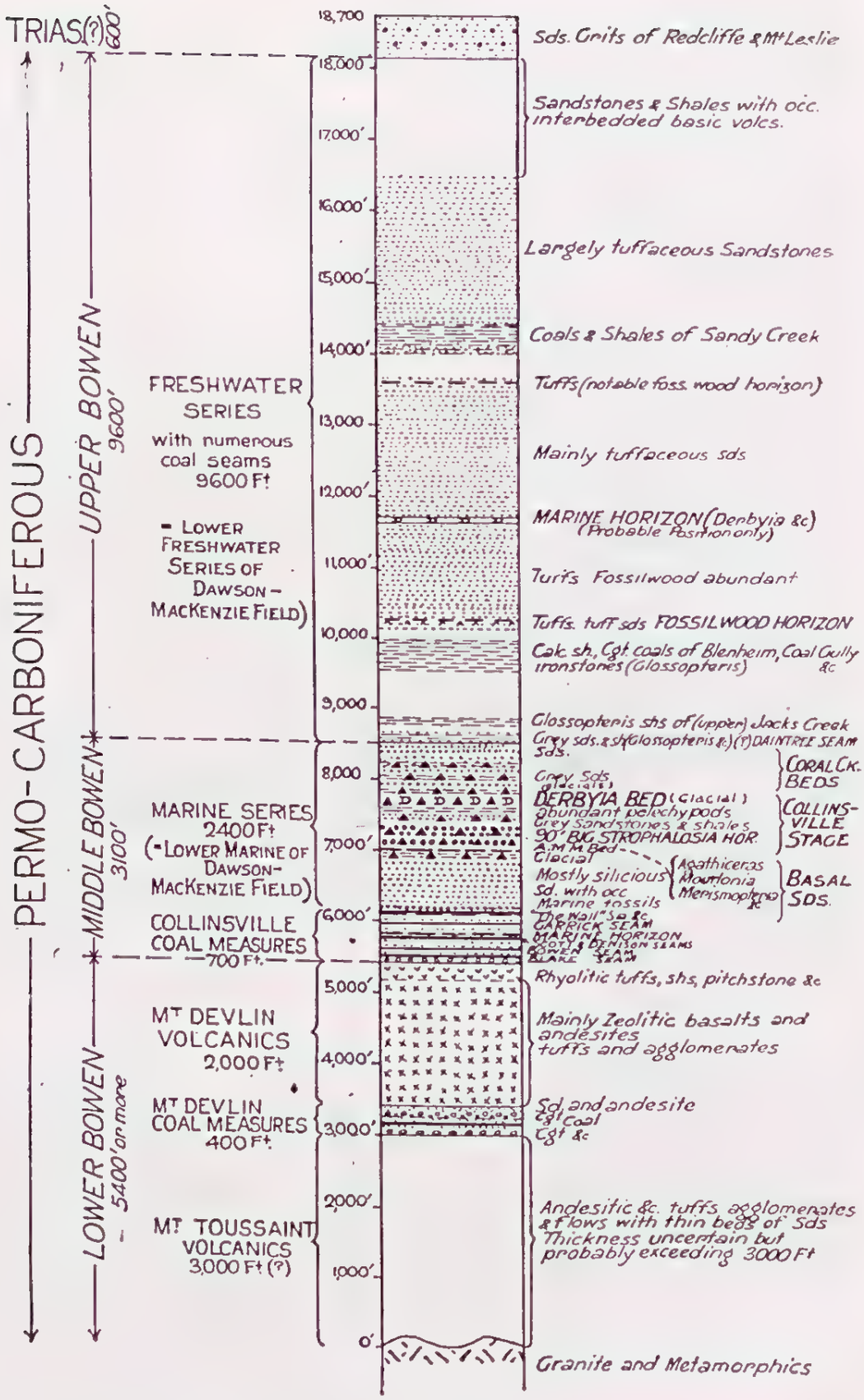


Fig. 22.—General Stratigraphical Section of Bowen River Coalfield.

base of the Mount Devlin Coal Measures at a point 20 chains north of the 45-mile peg. They consist mainly of coarse rhyolitic and andesitic agglomerates. Hard, dark-coloured sandstones dipping south are interbedded with them in a gully

about 5 chains south of the 44-mile peg. The section is estimated to represent a thickness of probably 3,000 ft. at least, but great variation is to be expected.

These beds are probably not represented in the extensive volcanic plains of Strathmore to the west, where occasional sandstone ledges outcrop which are interbedded with the volcanics, as, in the one traverse made of the greater portion of that plain, rhyolitic rocks were not met with.

Mount Devlin Coal Measures.

The Mount Devlin Coal Measures (thickness 400 ft.) are exposed immediately west, north, and east of Mount Devlin as a result of the structural elbow bends in the strata due to compressive folding along a N.N.W.-S.S.E. axis. The angles of dip are gentle to the S.S.E. (0°-25°) and steep at right angles to the fold axis (30°-90°) in either direction. The coal measures are well exposed in creeks and cuttings between 44¾ miles and 45½ miles on the railway, as well as along the Bowen road immediately west of Mount Devlin. Lying on a bed of basal conglomerate there is a succession of sandstones, containing an unworkable seam of coal occurring 100 ft. above the basal bed. The seam contains 3 ft. 10 in. of inferior coal, and the section has already been given in the chapter on Coal Resources. The strata carrying the coal were apparently unsuitable for the preservation of plant remains for an exhaustive search at the shaft dump did not reveal any identifiable fossil plants. The overlying beds are practically wholly sandstone, but contain several further conglomerate beds, and near the top of the measures alternate with thin lava flows of andesitic or basaltic character. The section along the railway line dips at an average angle of about 15° between south-east and south-west bearings, and disappears beneath the Mount Devlin volcanics near the 45½-mile peg.

Mount Devlin Volcanics.

Sections of the Mount Devlin volcanics are perhaps best seen in the railway cuttings between 45½-mile and 47½-mile pegs, also in the volcanic ridge 300 yards north of the State Colliery, and on the road from the State Colliery to the west of Mount Devlin. These sections are rather uniform in that a prominent ridge of rhyolitic tuffs, pitchstone, &c., occurs in each section at or close to the top, and that the middle and lower beds are composed of intermediate to ultra-basic lavas, tuffs, and agglomerates. The upper rhyolitic beds form rugged rocky ridges, half encircling the town of Collinsville, and vary in thickness from 100 ft. to 250 ft. in its environs. These volcanics have been picked up at intervals right along the eastern boundary of the field as far south as Blenheim, 50 miles south-east of Mount Devlin. Both andesites and rhyolites occur at the heads of Coral and Belmore Creeks. Just south of the head of Jack's Creek rhyolites are highly developed with a thickness of about 1,400 ft.

Rhyolites occur at Gebbie's Creek, on the Emu Plains road, and at the crossing of the Bowen River where a section on the southern bank shows the sequence noted at Mount Devlin—i.e., rhyolitic tuffs underlain by andesitic and basaltic tuffs. The outcrops in this section are not continuous enough to assert that

Fig. 23.—Rhyolitic Tuffs, &c., the Uppermost Horizon of the Lower Bowen Formation, near Collinsville.

these all belong to the Mount Devlin group. Assuming an average dip of 50°, a thickness of at least 2,500 ft. is represented by volcanics. The rhyolitic tuffs there are well bedded, reddish in colour, contain tiny veinlets of white quartz, and are associated with greenish tuffs and sandstones. That the volcanics extend past Blenheim is indicated by the blacksoil plain, several

miles wide, between the Homestead and the Broken River Range. Basic volcanic rocks also outcrop there to a slight extent in Dingo Gully, on the Blenheim-Eungella road, but the plain is practically devoid of outcrops.

The Mount Devlin volcanics are estimated to be approximately 2,000 ft. thick, based on the N.E.-S.W. section exposed along Pelican Creek and the railway line, just to the north-east of the Collinsville Town Reserve. In this section a width of 40 chains is exposed between the Mount Devlin Coal Measures and those of Collinsville, and the dip angle increases from 35° on the north-east to 80° on the south-west. (*See Fig.* 11.) The conformable junction of the volcanics and the Collinsville Coal Measures is exposed in the railway cutting at 47½ miles, where they dip towards the south-west at an angle of 80°, and together form one side of an extremely narrow syncline where these measures and portion of the Marine Series have been squeezed in and faulted.

At Collinsville the uppermost volcanics are mainly rhyolitic tuffs which are exposed 300 yards north of the State Colliery. This horizon is seen in prominent ridges within the surveyed township area. Below it occur agglomerates, tuffs, with andesites and basalts (zeolitic). These are seen on the flats just to the north-west of the town and in the railway cuttings north of 47½-mile peg. In the latter locality there are several beds of coarse agglomerates composed principally of boulders of andesite.

General Extent of Volcanics, &c.

The Lower Bowen volcanics cover a large area to the north-west and west of Collinsville, comprising Strathmore and Birralee holdings. They are known to extend across the Bowen River at Strathbowen R.O. and Birralee, but have not been mapped there. On Strathmore they extend for over 10 miles in an east-west direction in country which is but gently undulating. This is due to gentle folding and repetition of strata by reverse dips which are noted on the map of the field. The volcanics as developed there appear to belong more to the Mount Devlin Series than the Mount Toussaint. Basic tuffs are found perfectly bedded at Strathmore Homestead in a gentle syncline exposed in the creek. The series as a whole in this country appears to be of ultra-basic to intermediate composition.

There are several conspicuous sandstone stages in the vicinity of Upper Strathmore Creek along the road to the Homestead. The Bowen road from Strathmore to Table Mountain is over undulating volcanic country with several notable sandstone ledges cropping out, and also reaches of sandy soil amongst the volcanic soil indicating unexposed sandstones. At the Bowen River crossing (Strathbowen R.O.) there are at least several hundred feet of sandstones, &c., dipping at 20° to 30° towards east by north. On a traverse by road from Strathmore to Birralee volcanics are seen to occur to within about 5 miles of

Birralee, and they then give place to sandy soil without outcrops, although Birralee itself is on basaltic rock. The overseer there, Mr. Murphy, informed me that sandstone occurs in the river in this locality. In every instance where evidence was available these sandstone beds were found to be interbedded with the volcanics. In only one locality was fossil evidence found bearing on the age of the Lower Bowen. The sandstones at Bowen River Crossing, Strathbowen, contain *Glossopteris in situ.* It may be mentioned that this fossil fern is very abundant at this locality in loose specimens, but there is a possibility that they have come down the river from the higher beds. The horizon of these sandstones is not fixed in the Lower Bowen. It, however, cannot be higher than the Mount Devlin Coal Measures, and is almost certainly the equivalent of them.

The Lower Bowen in this field has not yet yielded any positive evidence of glacial beds. There are very few boulder beds, but several of such occur in the Mount Devlin volcanics at the 46-mile railway peg in a cutting offering clear exposures. The boulders consist entirely of basalt and andesite; they vary in size from large to small, and are not rounded noticeably. As the glacials in the Marine Series of the field are composed mainly, if not entirely, of granite, porphyry, and crystalline schists, it appears that their absence is very strong evidence against these particular boulder beds being in any way connected with glacial action apart from their other characteristics which do not support that supposition.

They are possibly fluvio-volcanic beds of very local distribution and in insignificant amount compared to the thickness of the series.

Age of Formation.

Jack regarded the Lower Bowen as of Permo-Carboniferous age. Jensen* has recently proposed to place it in the Upper Carboniferous—together with the Middle Bowen Formation as defined by Jack—and has linked it up in part with the Kuttung Series of New South Wales amongst others. David† has stated that the Kuttung Series is probably represented in Queensland by "the coarse basal conglomerates underlying the Bowen River Coalfield."

The *Glossopteris* found at Strathbowen, Bowen River Crossing, on an horizon at least 2,000 ft. down in the Lower Bowen Formation is actually the first recorded fossil evidence from it in the type district. Jack stated that he did not find any organic remains in it. Walkom‡ describes a number of specimens as from the Lower Bowen of the type district, but they are all from much

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* H I. Jensen. *Op. cit.* Table of correlation opp. p. 157.

† C. A Sussmilch and Sir T. W. E. David. Sequence of the Carboniferous Rocks of the Hunter River District, N.S.W. Journal Roy. Soc. N.S.W., vol. liii., p. 294, 1919.

‡ A. B. Walkom. Palæozoic Floras of Queensland. Part I. Q.G.S. Pub. 270.

higher horizons than this formation as defined by Jack, which is that of the Mount Devlin Coal Measures. All those specimens listed by him from Cockatoo Creek, Rosella Creek, and McArthur's Creek are from the Upper Bowen Formation of Jack and not from the Lower, as reference to Jack's report and map of the coalfield shows. Those listed from "Three-mile Creek" and "1¼ miles N.N.E. of Bowen Coal Hut" are in the lowest beds of the Middle Bowen, and are apparently in the one locality and about the same horizon, as reference to Blake and Graff's unpublished MSS. map of the field in the Queensland Geological Survey Office indicates. They have noted *Glossopteris* shales, associated with tuffs, at several points on Three-mile Creek, and the specimens described were collected by them. The reference of these fossil horizons to the Lower Bowen is apparently based on the extension of the provisional classification of the Dawson-Mackenzie Coal Measures,* which, however, cannot be applied satisfactorily to the Bowen River Coalfield since it would include the whole of the Permo-Carboniferous rocks there, totalling a thickness of about 18,000 ft., in the Lower with no representatives in the Middle or Upper Bowen Formations. The Lower Bowen Formation has little or nothing in lithological character, nor any positive evidence of glacial action, to justify correlation with the Kuttung Series. The varve shales and fluvio-glacial conglomerates of the lastnamed have no parallel on the Bowen field so far as observed. Further, the Kuttung Series contains the *Rhacopteris* flora. The Lower Bowen on this field is considered to be of Lower Marine age (New South Wales Permo-Carboniferous), as suggested by Mr. Dunstan in 1914, based on (1) the occurrence of *Glossopteris* and coal in it, (2) the occurrence of Permo-Carboniferous fossiliferous marine beds in a similar volcanic series, overlain by *Glossopteris* bearing coal measures, in extra-Bowen areas, (3) the stratigraphical sequence of the coalfield, which strongly favours it. The evidence of age is considered further in discussing the correlation of the coalfield with the Hunter River (New South Wales) and Queensland areas.

THE MIDDLE BOWEN FORMATION.

(a) Collinsville Coal Measures.

These measures are now known in detail at the northern end of the coalfield, and this is principally due to the mapping of Blake and Graff, carried out under the direction of the Chief Government Geologist, and the diamond drill records in the possession of the Queensland Geological Survey. They are essentially a sandstone series without evidence of contemporaneous vulcanism, and of freshwater origin throughout except for one marine transgression of relatively short duration. Their weathering has imposed on the area where they outcrop a marked sterility in contrast to the rich volcanic soils of the underlying series, and even to the light reddish sandy soils of the overlying Marine Series.

* B. Dunstan. Q.G.S. Pub. 155, p. 22.

They have been mapped at intervals over a distance of about 48 miles, extending from the Bowen River 5 miles south of Birralee to the Bowen River at the Emu Plains road crossing. At the latter point there is probably little or no diminution in thickness, and presumably they extend much further south.

At Collinsville they have a thickness of 700 ft., and at the Bowen River (Emu Plains road) the estimated thickness is 600 ft. At the latter place the lower beds are exposed in a branch gully on the south side of the river, dipping conformably with underlying rhyolitic tuffs at an angle of 65° towards the south-west. The measures exposed there consist of white and yellow sandstones with bluish sandy shales and carbonaceous shales, all of which contain abundant impressions of fossil wood and indeterminable plants. No coal seams are showing, but Mr. C. C.

[*Photo. by J. Conway.*

Fig. 24.—View Looking North-east to Clarke Range, Collinsville; Coal Measures in Foreground.

Morton, of the Queensland Geological Survey, has since informed me that an outcrop of a coal seam, probably 5 ft. thick, occurs in a gully near the Bowen River gold workings between Basin and Gebbie Creeks and about 200 to 300 yards behind "The Wall" sandstone (basal marine bed). This occupies the same stratigraphical position approximately as the beds just mentioned on the Bowen River, and is about 3 miles north-west therefrom. Daintree records three coal seams in this locality under the marine beds.* The coal measures are also well exposed on the Birralee-Collinsville road, on the western side of the syncline, where they have an average dip of about 5° to E.N.E., and consist, as at Collinsville, mainly of white and ferruginous sandstones.

Section of the Coal Measures at Collinsville.

In order to facilitate comparison with the accompanying sections (A and B) this description reads downwards from the top to the base.

* R. Daintree. Geology of Queensland. Quart. Jour. Geol. Soc., London, vol. xxviii., p. 286, fig. 9.

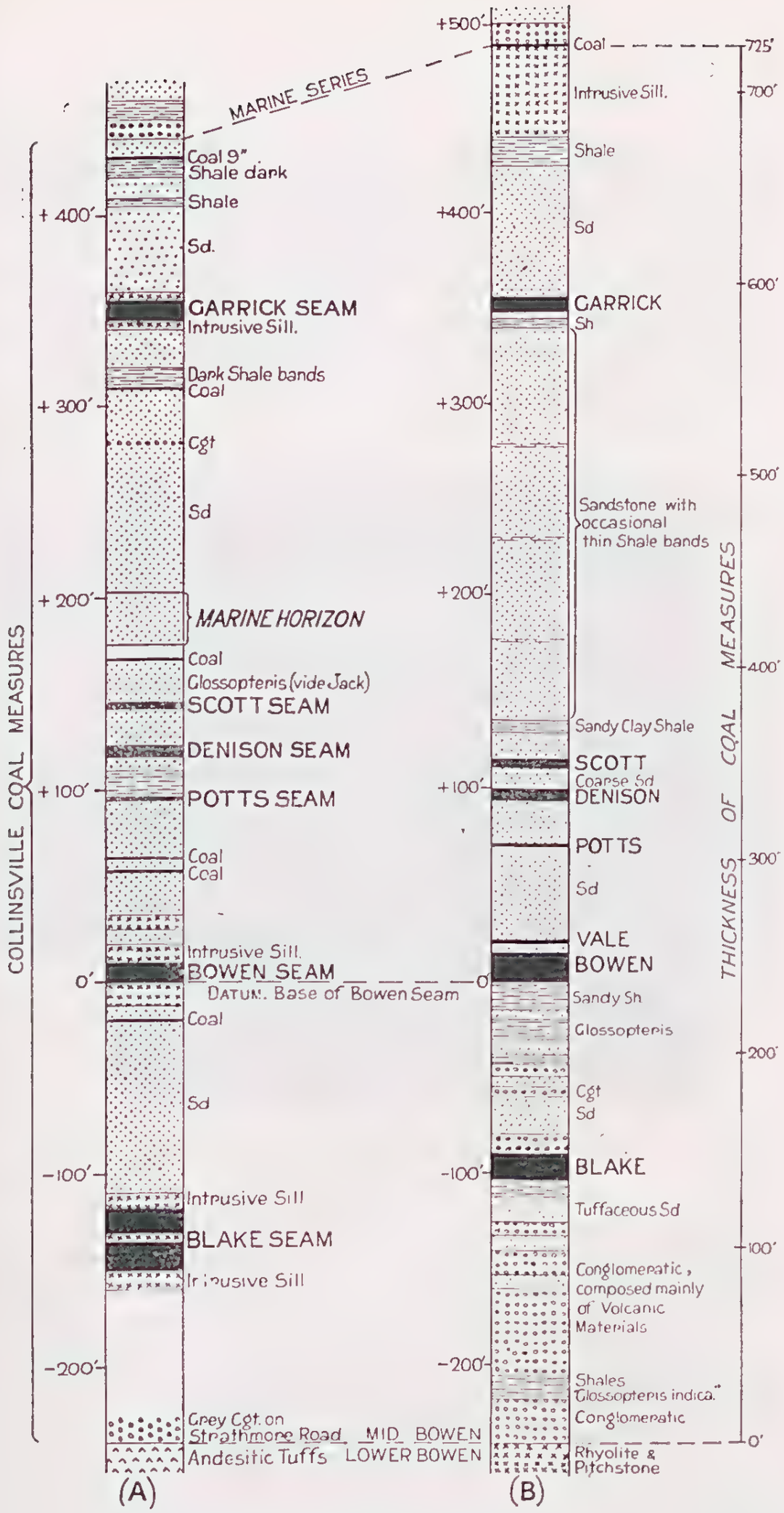

Fig. 25.—Vertical Section (to Scale) of Collinsville Coal Measures.
A. No. 2 State Reserve.
B. State Colliery, Collinsville.
(Based largely on Drilling Records.)

The basal bed of the Marine Series at Collinsville as shown in the bore records consists of grey pebbly conglomerate, with shell fragments, from 3 ft. to 10 ft. thick. A thin band of coal up to 1 ft. 6 in. thick occurs within a few feet of it. White, yellow, and grey sandstones with shale bands persist to the Garrick Seam which varies in position from 85 ft. to 135 ft. below the base of the Marine Series. A thin coal seam, varying up to 2 ft. 3 in., is persistent in the Collinsville area at an horizon 30 ft. to 40 ft. below the Garrick. Sandstones predominate from this seam to an underlying marine horizon.

Fig. 26.—Fault in Coal Measures, Pelican Creek, near No. 1 Bore.

Marine Horizon.—This occurs from about 150 ft. to 175 ft. below the Garrick Seam, and its base is 27 ft. above the Scott, as recorded in Bores Nos. 5 and 26. In the latter it is shown to be 25 ft. thick, and consists of dark-grey calcareous sandstone containing fragments of marine shells. Blake and Graff's unpublished map of the field shows that they have partially traced the outcrop of this horizon over a distance of about 8 miles from a point near Pelican Creek, about ¾ mile south of No. 1 bore, to a point 1 mile north of No. 5 bore, but it does not show what fossils were collected from it. This horizon has not been mapped east of No. 5 bore, and has not been recorded in any of

the rather numerous bores in that portion of the field. A section of strata about 50 ft. vertically above the Scott Seam is exposed in a tramway tunnel at the State Colliery, and an examination of that section was not successful in finding the marine bed, but in the ballast on the tramway procured from the tunnel faint impressions of pelechypods were found, and on account of the position they were obtained from there can be scarcely any doubt that they came from this marine horizon. These impressions were too poorly preserved for even generic determination. The horizon apparently represents a slight inundation of a portion of the field by the sea.

[*Photo., J. Conway.*

Fig. 27.—View near Collinsville; Typical Country of the Marine Series.

The Scott and Denison Seams are never more than 20 ft. apart. Although most of the bore sections show sandstones overlying the former seam, these are largely sandy clay shales in the No. 1 State Reserve, and their weathering has given rise to prominent crops of ironstone, useful there for determining the position of the Scott Seam. Between the Scott and Denison is a bed of hard siliceous sandstone about 10 ft. thick, which marks their horizons very well to the east of the State colliery. The Bowen Seam lies from 80 ft. to 120 ft. below the Denison, and this section, which is chiefly sandstone, contains the Potts Seam. The sandy shales lying close to the Bowen Seam contain very abundant impressions of *Glossopteris* and *Noeggerathiopsis* (?). They are poorly preserved, but are found in great numbers at the dead-end railway cutting at the State Colliery. The interval

between the two chief seams—the Garrick and the Bowen—is about 340 ft. to the south of the State Colliery, and about 390 ft. in the vicinity of the Consolidated mine. The Blake Seam lies 90 to 120 ft. below the Bowen, separated by sandstones and shales which are characterised by increasing amounts of volcanic detritus. It varies from 6 ft. thick near the State Colliery to upwards of 23 ft. in the No. 2 State Area. It contains a great deal of carbonaceous shale, and may be too inferior to mine while the other seams are available. The Blake Seam lies approximately 100 ft. above the topmost volcanic flow or tuff-bed of the Lower Bowen Formation. This 100 ft. consists variously of sandstones, grits, and small pebbly conglomerates—occasionally coarse—intermingled with bands of black and grey *Glossopteris* shales. With the exception of the shales, these rocks mostly consist of recognisable volcanic material in a decomposed condition from depths as great as 700 ft. (in Bore 13). Their pebbles and quartz grains are water-worn, and they are considered purely sedimentary, and as deriving their decomposed volcanic material from the tuffs and flows of the immediately prior formation.

Fossil Plants.

These coal measures have not supplied many specimens of fossil plants, except in tuffs and shales in their basal beds; probably owing to the sandy nature of most of the strata being unfavourable for preservation. Jack did not record collecting any recognisable plants from localities in the Middle Bowen, which can now be relegated to these measures. He cites Daintree as collecting *Glossopteris* from Pelican Creek (p. 32). In the record of No. 1 Bore he noted *Glossopteris* at 303 ft. and 309 ft., which places it on the same horizon as the Scott Seam. Walkom* has listed *Glossopteris indica, Noeggerathiopsis Hislopi,* and *Dadoxylon Arberi* from 1¼ miles N.N.E. of Bowen Hut, which locality places them in the basal beds of the Collinsville coal measures on an approximate horizon to those listed from Three-mile Creek, which comprise—

Glossopteris indica,
Glossopteris ampla,
Glossopteris Jonesi,
Nummulospermum bowenense.

The genus *Gangamopteris* has not yet been recorded, but considering the limited amount of identifiable material collected, it may yet be found. *Glossopteris indica* occurs well preserved in great abundance in grey shale near the 47½-mile peg, just north of the Collinsville Railway Station, also in black shale at a depth of 600 ft. in No. 13 Bore. Both these horizons are practically at the base of the measures. Specimens of *Glossopteris* have been found at various points in strata close to the horizon of the Bowen Seam. Generally speaking,

* A. B. Walkom. *Op. cit.*, p. 41 (table).

specimens appear rather rare in the surface rocks, with the exception of a few basal beds, although a suitable bed may yield many individual specimens.

Age.

These coal measures are considered to be the equivalent in age of the Lower or Greta Coal Measures of New South Wales. The *Glossopteris* flora is present in both, but it is scarcely possible that *Gangamopteris* will ever be found to be the predominating form as in the Greta Measures. *Glossopteris sp.* has now, however, been found at an horizon at least 2,000 ft. lower than the Collinsville Coal Measures, and this, in addition to the important coal seams in them, the marine-glacial beds immediately overlying and the Lower Bowen volcanics underlying them, which are found in the Mackay and the Styx districts, to contain Permo-Carboniferous marine horizons (*Eurydesma cordatum*, &c.), all strongly support this correlation.

(B) Marine Series.

Only one series containing a marine fauna occurs on the field, apart from two distinct marine horizons found interbedded with freshwater sediments. At the close of the coal-bearing period of Middle Bowen age, the basin was inundated progressively to the northwards by an invasion of the sea, for the lower beds of the series (i.e., the basal sandstones) are not represented at the northern apex of the field. Altogether a maximum thickness of 2,400 ft. of marine strata was deposited in the area to the north of the Bowen River before the sea retreated. The thickness of the series appears to increase proceeding southwards, and at Black Gate, near Blenheim, it is estimated to roughly approximate 3,000 ft. at least. The series is of great importance for the purpose of correlating the productive coal measures both below and above it with other Australian coalfields of Permo-Carboniferous age, and it is particularly noteworthy in two respects—its great wealth of marine fossils and the conspicuous evidence of glaciation during the period of its deposition. These have been brought to notice by Jack and other observers.

The series consists essentially of soft sandstones, shales being very subordinate and limestones, of any note, absent. Some few of the sandstones—e.g., the Big Strophalosia bed, are crammed with the calcareous tests of shells, and limy bands occur in these. This horizon to the south of the Consolidated mine is marked by a great deal of secondary limestone derived by alteration from the shells, but in other parts it is purely a sandstone, although crowded with calcareous tests. Conglomerates appear to be almost entirely absent; at least no useful horizons were observed, although the bores near Collinsville passed through a basal bed, 3 ft. to 10 ft. thick. Grey sandstones probably predominate throughout the series, and when these contain fossils the tests are

Fig. 28.—Typical Shell Sandstone of the Big Strophalosia Horizon (up to 93 feet thick), Crowded with Strophalosia Clarkei (Eth.), Fossil Hill, Collinsville. (Natural Size.) [*Photo., Sanderson.*

usually preserved; the great bulk of the fossils, however, are merely casts in ferruginous bands in sandstones. Fine-grained, greenish and micaceous, mudstones and sandstones are also well developed. Shales are usually sandy. The series gives on weathering soft and limy rock-faces and light-red, sandy (and non-calcareous) soils. Possibly one of the most remarkable fossil horizons in Australia occurs on this field. This is a bed of sandstone packed with *Strophalosia Clarkei* for the full width of 93 ft., as exposed on the north bank of the Bowen River, about ½ mile downstream from the Emu Plains crossing, and referred to generally in this report as the Big Strophalosia Horizon. Other forms occur in very subordinate numbers in this bed. Four miles further north-west a thickness of 60 ft. is seen alongside the Collinsville road. At Collinsville, this horizon is conspicuous on the west bank of Pelican Creek, where the present water supply is pumped from, and *Productus brachythœrus* is a very common form in it there also. In Carpet Snake Creek, near its mouth, and on "Fossil Hill," and in Corduroy Creek, the bed is estimated to be about 60 ft. thick. The section of it on Carpet Snake Creek is from 50 ft. to 60 ft. thick, of which the upper 35 ft. is solidly packed with *Strophalosia*. This bed is doubtless to be connected with a section 51 ft. thick, described by Jack as occurring in Stonehumpy Creek (Twelve-mile Gully on the present map), in which he stated "every bed was crowded with fossils, particularly *S. Clarkei.*" The calcareous tests are retained, and it forms a splendid horizon, which has been traced at intervals for about 40 miles. At Collinsville it is the key horizon, *par excellence*, for the coal seams underneath. Its base lies about 300 ft. above the base of the marines there, and the Garrick Seam lies, therefore, at a depth of from 400 ft. to 450 ft. below the lowest portion of its outcrop. Since it can be picked up continuously at the surface in the Collinsville district, with the possible exception of alluvial reaches in proximity to creeks, its great value as an index bed is obvious. The one drawback to it as an index bed, where it may be only partially exposed, is the fact that there are other Strophalosia beds, several of which have a thickness of 15 ft. to 20 ft. "The Wall" sandstone, also mentioned by Jack, which occurs at the base of the Marine Series, is another remarkable horizon along the eastern side of the field. Owing to the high angle of dip—35° to 70°—to the south-west, the hard sandstones of the basal beds stand out as sharply defined ridges, the western slopes corresponding to the dip angle in inclination, while the eastern slopes, steepened by truncation due to weathering along joints, are often inaccessible. They rise sharply from flat to undulating country, and stand out conspicuously, often as solid sandstones minus soils. From the heights of the Broken River Range, this horizon can be traced by the eye almost continuously for at least 20 miles, running in practically a straight line. Other beds besides the absolute basal bed occasionally form parallel sandstone ridges disposed

en echelon. The maximum height of these ridges above the surrounding country is 300 ft. to 400 ft.

Two other fossil horizons of local value as index beds are worthy of mention here. The first is the *Derbyia senilis* bed exposed in Corduroy, Pelican, and Coral Creeks, between Collinsville and Sonoma. This bed is the only one in the Marine Series in which the writer has observed the presence of *Derbyia,* although it has been stated to have been found in other localities which would certainly separate it from this bed. This particular

Fig. 29.—Characteristic Outcrops of "The Wall" Sandstone, showing Dip Slopes, near Emu Plains Crossing of Bowen River.

one is, however, easy of identification, because it lies immediately under a bed of glacial till. It occurs in a brown calcareous sandstone, intensely hard, which is crowded with shell remains of *Derbyia* almost to the total exclusion of other forms, and varies from 1 ft. to 18 in. in thickness. It has been traced at intervals for nearly 2 miles to the west and north of Sonoma, and is estimated to be about 350 ft. above the Big Strophalosia bed. The Garrick Seam can, therefore, be anticipated to lie roughly from 850 ft. to 950 ft. below its outcrop near Sonoma.

In the vicinity of Pelican Creek, near the big U bend in it—i.e., about 6 miles south-west of the Consolidated mine—an

Fig. 30.—"The Wall" Sandstone in Creek at Blenheim Homestead, showing Joint Faces (not Dip).

Astartila bed forms a useful horizon for locating the position of the Garrick Seam. This is a sandstone bed, often hard and very calcareous, crowded with this small pelechypod. It is about 1 ft. thick, and in the cliff sections along Pelican Creek it is found to lie 25 to 30 ft. above the Garrick Seam. It has not been observed elsewhere than in the area adjacent to the creek there. It appears to occupy the same position relative to the Garrick Seam as the bed observed by Daintree in this locality, and cited by Jack,* which was described as an arenaceous limestone band with abundant specimens of *Streptorhyncus crenistria* (= *Derbyia senilis*). The writer did not observe this particular

* R. L. Jack *Op. cit.*, p. 16.

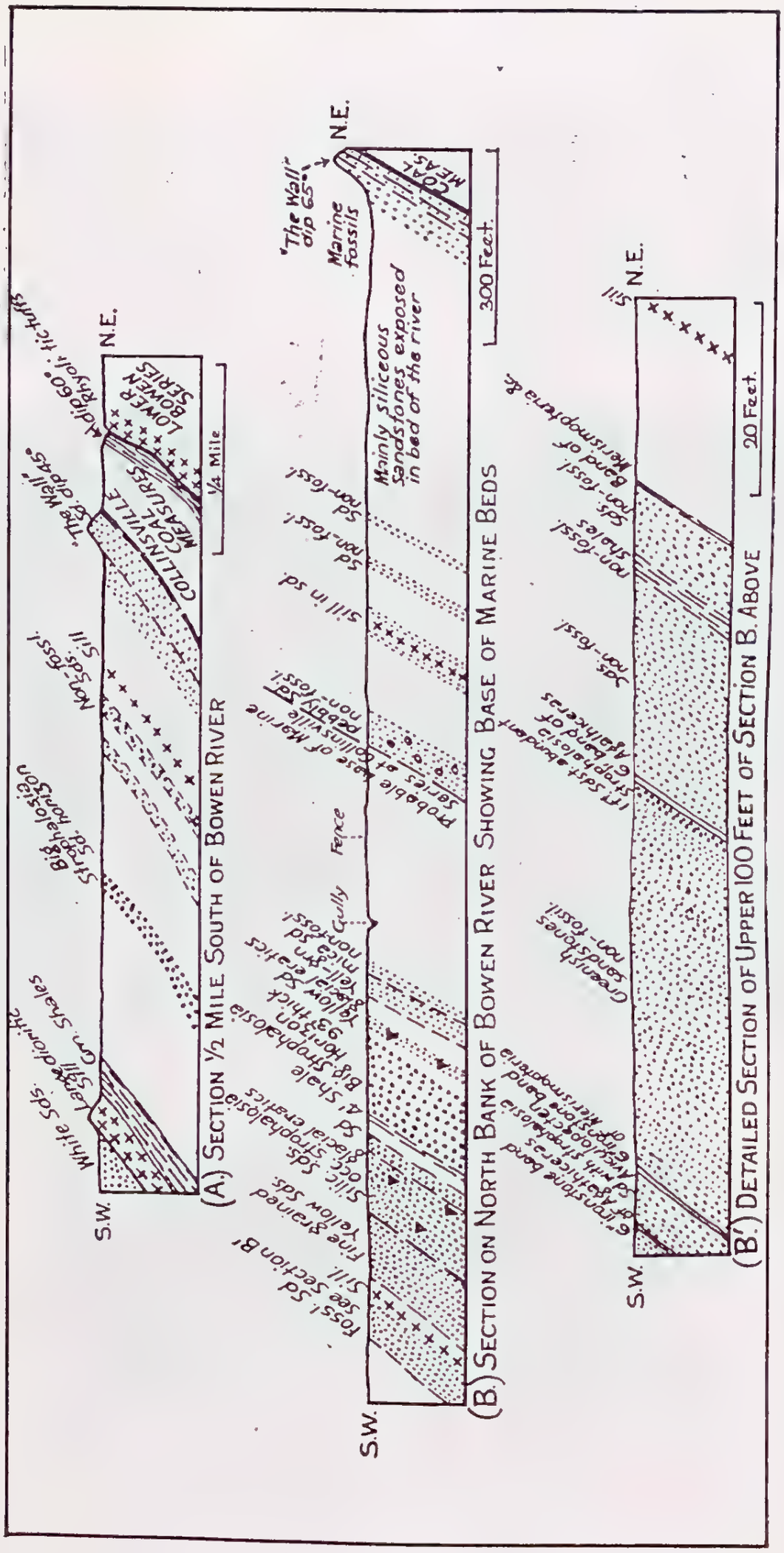
(A.) Section ½ Mile South of Bowen River
S.W.
N.E.
¼ Mile
Collinsville Coal Measures
Lower Bowen Series
Mainly siliceous sandstones exposed in bed of the river
Marine fossils
"The Wall" dip 65°
Coal Measures
(B.) Section on North Bank of Bowen River Showing Base of Marine Beds
300 Feet.
(B'.) Detailed Section of Upper 100 Feet of Section B. Above
20 Feet.

Fig. 31.—Geological Sections of Middle Bowen Marine Series, &c., near Emu Plains Crossing of the Bowen River,

genus in this locality, and Jack, who describes the particular section to which he attributes Daintree's remarks regarding the occurrence of this fossil, has not recorded it either from the section.

From the geological sketch map accompanying this report it will be seen that the Marine Series forms a fringe around the Upper Bowen Formation, the structure being an immense syncline. The narrow outcrop on the east is due to the relatively steeper dip. In a southerly direction it has been traced to within about 5 miles of the "Lower Marine" Series, as mapped by Cameron at Mount Britton. The Mount Britton marine beds and the Bowen Series are identical in part, for they are in direct line and contain largely the same fossil assemblage. By means of Cameron's mapping from Mount Britton to the Mackenzie River,* the connection of the Middle Bowen Marine Series with the "Lower Marine" Series of the Dawson and Mackenzie River fields is considered to be definitely established.

General Description of Marine Sections.

The columnar section of the series gives a generalised vertical section showing the more important fossil horizons. The lower 800 ft. of strata (basal sandstones) are exposed, as far as known, only along the eastern belt south of a point a few miles north of the Bowen River. They possibly occur also on the west side of the field to the south of the river. The marine sections on the eastern side have been studied at the Emu Plains Crossing, Blenheim, and Hazelwood Creek. Those at the former locality are the most complete. The Blenheim section is confused by earth movements, indicated by vertical strata and irregular dips. Strophalosia beds occur there in Blenheim Creek, and a good collection of fossils can be obtained on the road ¼ mile north of the homestead. The basal sandstones, consisting almost entirely of white and grey siliceous sandstones, thin out northerly from the Bowen River, the last outcrop of "The Wall" being just to the south of the projection of the metamorphic rocks across the strike lines of the marine beds. The Big Strophalosia horizon continues after a gap on past this point in the expected strike line, and the lower beds are apparently overlapped.

Fossils are rare in the basal beds, but from the bottom of the first "Wall" south of the Bowen River at the Emu Plains Crossing the sandstones yielded:—

Deltopecten subquinquelineatus
Dielasma (*?*)
Stenopora (*?*)
A gasteropod cast.

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* W. E. Cameron. Q.G.S. Pub. 200.

Above the basal beds, the Bowen River section shows about 780 ft. of overlying strata, of which the upper 450 ft. is practically complete on the northern bank (*see Fig.* 31*b*). This 780 ft. is represented at Collinsville. The lowest exposed fossil horizon at the Bowen River (south side), excluding the lastmentioned occurrence, is a bed of ferruginous sandstone, about 160 ft. above the top of the basal sandstones, characterised by *Agathiceras*,* *Mourlonia*, and *Merismopteria* (the A.M.M. bed), but containing abundantly other genera, which can be correlated with a similar fossil bed on Corduroy Creek, 20 chains south of the railway. This bed is also about an equal interval below the base of the Big Strophalosia bed in both localities. Below this horizon, however, are the fossil beds exposed at the railway bridge across Carpet Snake Creek, Collinsville. A thickness of 17 ft. there largely consists of *Strophalosia*, and then above a 10-ft. interval of grey sandy shale there is a prolific horizon for *Aviculopecten* and other pelechypods. A few feet below this section are shales with *Protoretepora*. These beds are possibly midway between the top of the basal sandstones and the A.M.M. bed. The interval between the latter and the bottom of the Big Strophalosia bed is almost 150 ft., and a section on the east side of Corduroy Creek, between the two, shows sandstones chiefly with thin ironstone bands containing, particularly, *Agathiceras* and *Chænomya* in abundance, also *Cleobis* and other pelechypods. Summarising, the 300 ft. of strata in the Collinsville district below the Big Strophalosia horizon is characterised by ironstone bands and ferruginous concretions in sandstones and shales, and contains a wealth of pelechypods (*Cleobis*, *Chænomya*, *Merismopteria*) and also *Agathiceras*. Glacial erratics are also common throughout this zone. This portion of the section is not revealed at the Bowen River (*see B, Fig.* 32).

Some description of the size and character of the Big Strophalosia horizon has already been given. At the Bowen River, where the fossiliferous 93 ft. is completely exposed, it contains numerous glacial pebbles, and is underlain by a single layer of *Chænomya Etheridgei*, and 30 ft. under this is a yellow sandstone with many small erratics. At "Fossil Hill," near Collinsville, *C. Etheridgei* is very abundant 10 ft. below the Big Strophalosia bed, and generally this species appears to have its greatest development in the 150 ft. below it, although it is also found on higher horizons. The stratigraphical section above the Big Strophalosia horizon is well exposed for 300 ft. at the Bowen River, and for about 400 ft. in Corduroy Creek. This contains further beds of *Strophalosia* which outcrop in Pelican Creek, near Oakey Creek junction, and again below its junction with Coral Creek. The 400 ft. in Corduroy Creek largely consists of hard grey sandstones, with some shales and mudstones, and

* Since determined to be *Bellerophon;* see footnote, p. 80.

fossils are not conspicuous till the upper 150 ft. of this section is reached, when ferruginous bands, crowded with fossil casts, become frequent in the sandstones accompanied by glacial erratics. The fossils here are essentially pelecypods, *Chænomya, Merismopteria, Aviculopecten, Stutchburia*—also the brachiopod *Martiniopsis*—and above these the *Derbyia senilis* horizon is exposed 400 yards from the mouth of the creek at an interval about 350 ft. above the top of the Big Strophalosia bed. The glacial horizons hereabouts can be traced along Pelican Creek,

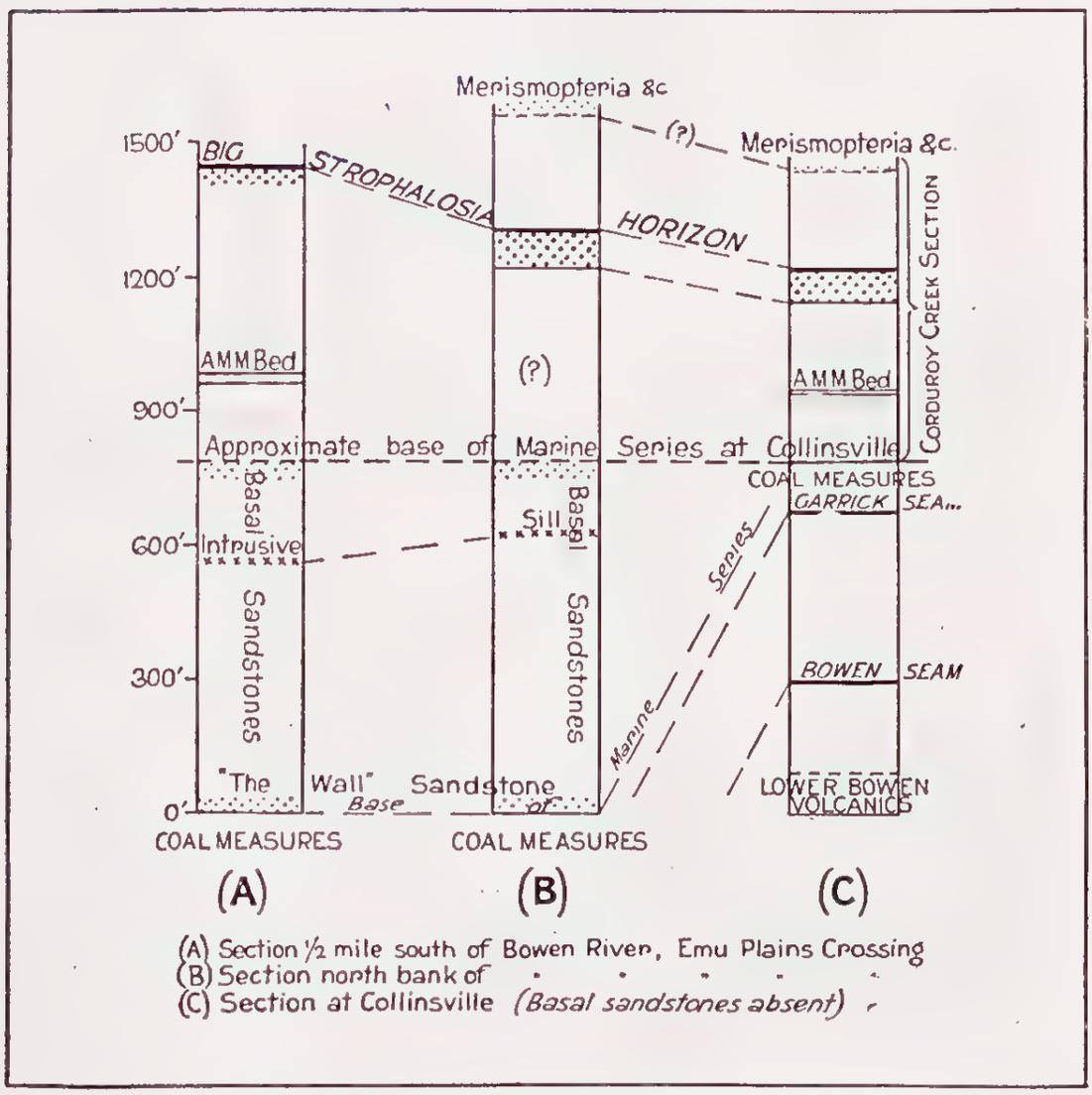

Fig. 32.—Correlation of Several Marine Horizons at Collinsville and Bowen River (Emu Plains Crossing).

which runs parallel to their strike for some distance towards the mouth of Coral Creek.

The section up Coral Creek, which is far from complete, represents probably the upper 800 ft. of the Marine Series, and the Upper Bowen Formation then comes into the creek about 3 miles east of Sonoma. There is a low angle of dip to the south-east throughout the greater portion of this section. Within half a mile west of Sonoma there are excellent exposures in Coral

Creek, already described by Jack, and the *Derbyia senilis* horizon again outcrops there underlying a glacial till up to 2 ft. thick. The Derbyia bed is at the base of the till, and is itself a calcareous sandstone, 2 ft. thick, with fine glacial debris through it, recemented by iron oxides, making it excessively hard and difficult to procure the fossils without breaking them. A large dendroid *Stenopora* (sp. cf. *ovata*) is the accompanying form, and there are impressions of crinoid stems. Glacial and fossiliferous sandstones continue easterly for 150 yards in the creek. The section dips south-east at 5°.

Above this section sandstones and shales on the roadside, just west of Sonoma Homestead, yielded poorly preserved specimens of a large *Strophalosia*. For 2 miles above the Coral Creek crossing of the Collinsville-Sonoma road occasional outcrops of sandstones are picked up, several of which have small pebbles which are probably glacial, but have no fossil remains. The topmost marine beds do not appear to be exposed in this section. On Hazlewood Creek, which lies about 50 miles south-east of Coral Creek, marine sandstones occur which represent either the uppermost beds of the Marine Series or those very close to it. The Upper Bowen softer strata, however, are not exposed just immediately above this section adjacent to the creek. Crossing Hazlewood Creek, about 2¼ miles above Mr. Turner's house, is a prominent sandstone ridge covered with rosewood. The sandstones in it are notably coarse and more or less ferruginous, and dip to the south-west at angles of 60° to 65°, and strike north 40° west. They form the starting point of the Exe Range, which closely follows this strike line, and near the other end of which marine fossils have been collected by Jack. The first, or uppermost, identifiable marine bed is a prolific *Dielasma* and *Productus brachythærus* horizon accompanied by many other genera. The fossils are found abundantly in thin bands of ochreous ironstone following bedding planes in the siliceous sandstones which themselves appear devoid of fossils. These beds did not yield any glacial evidence. Further up the creek there are occasional exposures of greenish mudstones and sandstones containing *Spirifer tasmaniensis*, &c., very similar in character to certain of the marine beds exposed around Collinsville.

Brief mention should also be made of the sections of the upper portion of the marine beds at Jack's Creek and "Black Gate," Blenheim. Jack* has described and figured the section along Jack's Creek, east of the Emu Plains road, in which he shows the Upper Bowen beds thrown against the metamorphics. This interpretation, in omitting the Marine Series, is incorrect, doubtless due to the section being described from the creek bed where exposures are poor. A section taken nearly due east from the intersection of the creek and road (bearing away from the creek) strikes the rhyolites of the Lower Bowen within a short

* R. L. Jack. *Op.cit.*, p. 22.

mile. In this interval there are excellent exposures of one Strophalosia bed and other fossil and glacial horizons. As the marine beds are exposed 2 miles to 3 miles north of the creek at Belmore, it is seen therefore that some portion of them continues right through Jack's Creek. In this section some 50 yards west of the base of the rhyolites a bed of *Strophalosia* occurs, but as only about 450 yards (across the strike) of marine beds are exposed between the rhyolites and the Glossopteris beds of the Upper Bowen a thickness of only 1,200 ft. of marine strata can be accounted for at an average angle of dip of 65°. This makes the Strophalosia bed in all probability higher than the big horizon, and indicates that probably the overthrust faulting east of Collinsville extends as far south as Jack's Creek, and has resulted in the heaving of the Lower Bowen volcanics over the lower members of the marine beds and the Collinsville Coal Measures. The strike of the beds in this section is north, 15° west; the dip is to the south of west at angles ranging from 60° to 80°.

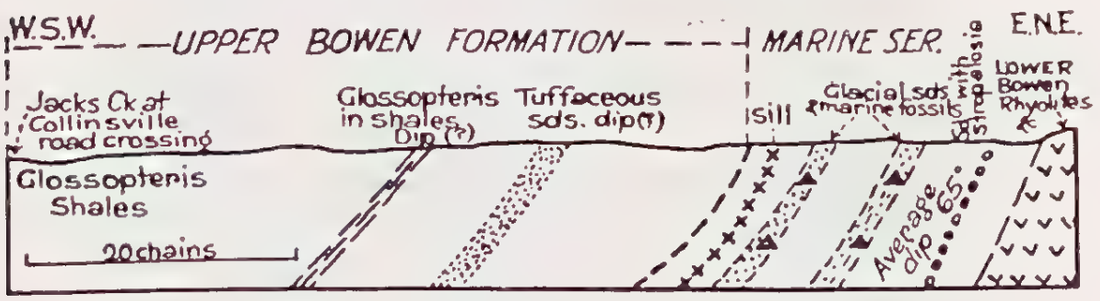

Fig. 33.—Sketch Section near Jack's Creek, East Side of Collinsville Road.

The "Black Gate" section is taken along the boundary fence which intersects the Collinsville road 8 miles north of Blenheim Homestead. Calcareous shales of the Upper Bowen are exposed 100 yards south of the gate, angle of dip 25° to the south-west, strike north, 55° west. In the half-mile proceeding east from the "Black Gate" there are no further outcrops, but at that distance ferruginous sandstone boulders with abundant *Strophalosia Clarkei*, and also *Martiniopsis*, are strewn about. One mile east of the gate *Mourlonia* and *Merismopteria* are found in ironstone material comparable with the A.M.M. bed on Corduroy Creek. This is at the base of a sandstone ridge dipping at 55° to the south-west, bands in which contain pelechypods, &c. A further half-mile to the east is another sandstone ridge, probably "The Wall" sandstone of the basal beds. As the width of the marine beds exposed is about 1 mile, and the angle of dip probably averages above 30° throughout the whole section, it is almost certain that the top beds are those where *Strophalosia* was found in loose boulders. *Productus farleyensis* was found there also. The Marine Series, on this section, appears to be increasing in thickness as followed to the south.

The upper section of the marine beds has also been traversed on the western side of the field between Cockatoo and Parrot

Creeks, almost due west of Mount Razorback and within 4 miles of the Leichhardt Range. A local eminence (Mount Sambo (?)) consisting of Tertiary strata overlies micaceous grey shaly sandstones from which no fossil evidence was obtained. Proceeding $1\frac{1}{4}$ mile westward over these a low ridge of siliceous sandstone strikes north 20° east and dips easterly at 7°. While this horizon is inconspicuous from the east, a rise of about 100 ft. in level is

Fig. 34.—Tillite Overlying Derbyia Horizon, Gully off North Bank of Pelican Creek, above Junction with Coral Creek.

apparent from the western side of it. This is considered to be most probably near the top of the Marine Series here, as in lithological character it agrees with the siliceous sandstones described in Hazlewood Creek. It also contains occasional boulders which are possibly glacial. The fossilised trunk of a tree was observed embedded in this sandstone. About half a mile west of this horizon, and approximately at an interval of 400 ft. lower, were found the typical coalfield marine beds consisting of fossiliferous greenish sandstone (*Spirifer, Tribrachiocrinis*, &c.) with erratics of schist, granite, &c. These dip 5° easterly. This section is

about 14 miles south of the marine beds on the Bowen River (western side of the field) which have been so fully described by Jack that a further examination of them later was not considered necessary.

The descriptions of the preceding sections show that the outcrops of the Marine Series extend right around the coalfield except on the south side, and it must be deduced that the beds continue, probably without interruption, across the field beneath the Upper Bowen Formation. The lower 600 ft. to 800 ft. of strata consists of basal sandstones, which, however, do not appear at the surface in the Collinsville district, where approximately the upper 1,600 ft. are represented. The series has yielded marine fossils from its base to what is considered to be its uppermost bed. There is unmistakable evidence of glaciation in the strata from at least 800 ft. above the base to within probably 800 ft. of the base of the Upper Bowen. The field is possibly more prolific in evidence of the Permo-Carboniferous Upper Marine fauna than any other field yet described in Australia.

Glacial Evidence.

Jack first noted this evidence, and he stated*: "Large isolated boulders of granite, &c., occur here and there in the midst of strata of fine sandy or muddy material. These could hardly have been brought to their present positions except by glacial action."

The evidence of glaciation is widespread and arresting despite the fact that none of the boulders examined appeared to be ice-scratched nor noticeably faceted. There are innumerable occurrences, however, of smooth rounded boulders often measuring up to 1 ft. in greatest diameter, found singly and at considerable intervals embedded in the finest of mud sediments. Further, there are the granite and schist erratics, measuring up to about 12 cub. ft. and weighing almost a ton, found weathering out of the fossiliferous beds on the hillsides (as at Fossil Hill), where neither granite nor schist outcrops are within miles of their positions. These are often angular, this being doubtless due to their disintegration along joints or cracks during the weathering-out process from the sediments. Nevertheless, there can be no possible doubt as to their origin. The erratics consist only, so far as observed, of granite, porphyries, and crystalline schists. The glacial evidence is particularly noticeable in the Collinsville portion of the field, and ranges from the base of the series as exposed there to at least as high as the Derbyia horizon, a thickness of 800 ft., but it probably extends higher.

A notable bed of tillite, about 2 ft. thick, lies immediately on the *Derbyia senilis* horizon, and is shown photographically in Fig. 34.

* R. L. Jack. *Op. cit.*, p. 7.

Fig. 35 (*a*).—Glacial Boulder (15 inches by 22 inches) in Fine-grained Mudstones, Corduroy Creek.

Fig. 35 (*b*).—Glacial Erratics of Schist in Big-Strophalosia Horizon, Carpet Snake Creek.
(Note Crowds of Disc-like Shells below Hammer (*Strophalosia Clarkei*).

The Marine Fossil Fauna.

A considerable number of species collected by Jack from the Marine Series in this field have been described by Etheridge.§ The following is a list of these compiled from the Geology and Palæontology of Queensland, pp. 199-299:—

Stenopora australis
Stenopora Leichhardtii
Stenopora Jackii
Protoretepora ampla var. Woodsii
Protoretepora ampla var. Koninckii
Dielasma cymbæformis
Spirifer convoluta
Spirifer Clarkei
Spirifer bisulcata
Spirifer tasmaniensis
Martiniopsis subradiata
Martiniopsis Darwinii
Derbyia senilis
Productus brachythærus
Productus subquadratus
Strophalosia Clarkei
Strophalosia Gerardi
Deltopecten subquinquelineatus
Aviculopecten limæformis
Merismopteria macroptera
Astartila cytherea
Chænomya (?) acuta
Chænomya (?) bowenensis
Cleobis grandis
Mæonia carinata
Mæonia recta
Solemya Edelfelti
Agathiceras micromphalus

Dr. F. W. Whitehouse, Hon. Palæontologist to the Geological Survey, has made an examination of the marine fossils collected during the recent survey of the field by the writer, and the following list embodies his determinations:—

MARINE SERIES OF THE BOWEN RIVER COALFIELD.

Records of new species similarly marked (by asterisk or other sign) refer to the same species.

CORDUROY CREEK, COLLINSVILLE.

Spiriferina duodecimcostata (McCoy).
Cleiothyris sp.
Merismopteria macroptera (Morris).
Mæonia carinata var. *minor* (Eth. fil.).
**Chænomya* sp. nov.
Astartila cf. *transversa* (Dana).
Astartila (?) sp.
Notomya (?) sp.
Stutchburia (?) aff. *cuneata* (Dana).
Mourlonia strzeleckiana (Morris).
†*Mourlonia* sp. nov.

FOSSIL GULLY, COLLINSVILLE.

Merismopteria macroptera (Morris).
Merismopteria aff. *macroptera* (Morris).
Aviculopecten tenuicollis (Dana).
Aviculopecten cf. *squamuliferis* (Morris).
Mæonia recta (Dana).
Mæonia sp.
‡*Plagiostoma* aff. *deltoideum* (Girty).
Cleobis cf. *grandis* (Dana).
Cleobis (?) sp.
Modiomorpha (?) cf. *mytiliformis* (Eth. fil.).

§ R. Etheridge, junr. Proc. Roy. Phys. Soc. Edinburgh, vol. 5, pp 263–328 (1880), *et* Geol. and Pal. of Queensland. (Jack and Etheridge). Q.G.S. Pub. 92 (1892).

Stutchburia sp. ind.
Stutchburia (?) aff. *cuneata* (Dana).
Solemya (?) sp. ind.
Chænomya Etheridgei (de Kon.).
**Chænomya* sp. nov.
***Bellerophon* (*Warthia*) *micromphalus* (Morris).
Naticopsis sp. nov.
Mourlonia Strzeleckiana (Morris).
†*Mourlonia* sp. nov.

FOSSIL HILL, COLLINSVILLE.
Strophalosia Clarkei (Eth.).

6 MILES S.W. OF COLLINSVILLE (near Three-mile Creek).
Furcaster sp. nov.

NEAR BORE 13, COLLINSVILLE.
Plagiostoma aff. *deltoideum* (Girty).
Mourlonia sp. juv.

CARPET SNAKE CREEK (RAILWAY BRIDGE), COLLINSVILLE.
Protoretepora Woodsi (Eth. fil.).
Notomya (?) sp. ind.

PELICAN CREEK.
Derbya senilis (Phillips).
Strophalosia cf. *Clarkei* (Eth.).
Spirifer sp.
Astartila (?) sp. ind.
Mæonia sp. nov.

PELICAN CREEK PUMPING STATION (Strophalosia bed).
Productus brachythærus (G. B. Sow.).

PELICAN CREEK (¼ mile below Pumping Station).
Hyolithes sp. ind.
Mourlonia cf. *Strzeleckiana* (Morris).

PELICAN CREEK (near old Garrick Adit).
Undetermined lamellibranchs (? *Astartila*, &c.).

CORAL CREEK (near Sonoma, from a Boulder).
Stenopora cf. Leichardti (Eth. fil.).
Posidoniella intumescens (de Kon).
Astartila cf. *polita* (Dana).
Bellerophon (*Warthia*) *micromphalus* (Morris).
Solemya (?) sp. nov.
Mourlonia Strzeleckiana (Morris).
Naticopsis sp. nov.

**A number of the reputed "*Agathiceras micromphalus*" from this field were sectioned. All are non-septate. The external ornament agrees with that of the type, as originally described by Morris, and which in turn differs from that of the definite ammonoid erroneously referred by Etheridge to this species (Recs. Geol. Surv. N. S. Wales, vol. iv., 1894, p. 36, pl. 7, figs. 9-14). Two similarly coiled species, a common gastropod and a rare cephalopod, have thus been referred to this one species by earlier writers.—(F.W.W.)

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[*Photos., Sanderson.*

FIG. 36.—TYPICAL MARINE FOSSILS OF THE BOWEN RIVER COALFIELD (MIDDLE BOWEN MARINE SERIES).

1. *Derbyia senilis* (Phillips), Pelican and Coral Creeks.
2. *Productus brachythærus* (G. B. Sby.), Hazlewood Creek.
3. *Chænomya Etheridgei* (de Koninck), Emu Plains Crossing.

SONOMA.

Zaphrentis (*Pleurophyllum* ?) sp. ind.
Stenopora ovata (Lonsd.).
Strophalosia sp. (large form).
Derbyia senilis (Phillips).

NEAR EMU PLAINS CROSSING (of Bowen River).

Stenopora cf. *crinita* (Lonsd.).
Spirifer vespertilio (G. B. Sow.), var.
Productus brachythærus (G. B. Sow.), var.
Strophalosia Clarkei (Eth.).
Astartila cf. *polita* (Dana).
Chænomya Etheridgei (de Kon.).
Bellerophon (*Warthia*) *micromphalus* (de Kon.).
Mourlonia Strzeleckiana (Morris).

NEAR ROSELLA CREEK ? HAVILAH.

Derbyia cf. *senilis* (Phillips).

BLACK GATE, 8 MILES NORTH OF BLENHEIM HOMESTEAD.

Productus farleyensis (Eth. fil. and Dun).
Productus cf. *farleyensis* (Eth. fil. and Dun).

DIVIDE BETWEEN PARROT AND COCKATOO CREEKS.

Tribrachyocrinus corrugatus (Ratte).
Fenestella sp.

HAZLEWOOD CREEK.

Dielasma sp. nov. (small species).
Spirifer cf. *convoluta* (Phillips).
Spirifer tasmaniensis (Morris).
Productus brachythærus (G. B. Sow.).
Productus sp. nov.
Aviculopecten cf. *Engelhardti* (Eth. fil. and Dun).
Astartila (?) sp. ind.
‡*Plagiostoma* aff. *deltoideum* (Girty).
Pachydomus (?) sp. ind.
Mourlonia sp.

THREE-MILE CREEK, BOWEN RIVER.

Mourlonia Strzeleckiana (Morris).

Of the more commonly occurring species none appear to have restricted ranges, so that it is difficult, if not impossible, to differentiate stratigraphical horizons on the species found in any particular bed. *Strophalosia Clarkei* is by far the most abundant and characteristic species. It is present in enormous numbers in the lower half of the Collinsville beds, but has not been found in the higher beds of Coral Creek by either Jack or the author. It is abundant, however, in the upper beds of the series, both at Hazelwood Creek and near the "Black Gate," Blenheim. It is not recorded so far in the marine horizon in the Upper Bowen Formation. *S. Gerardi* has been described by Etheridge from localities which probably place it in the Collinsville beds. The

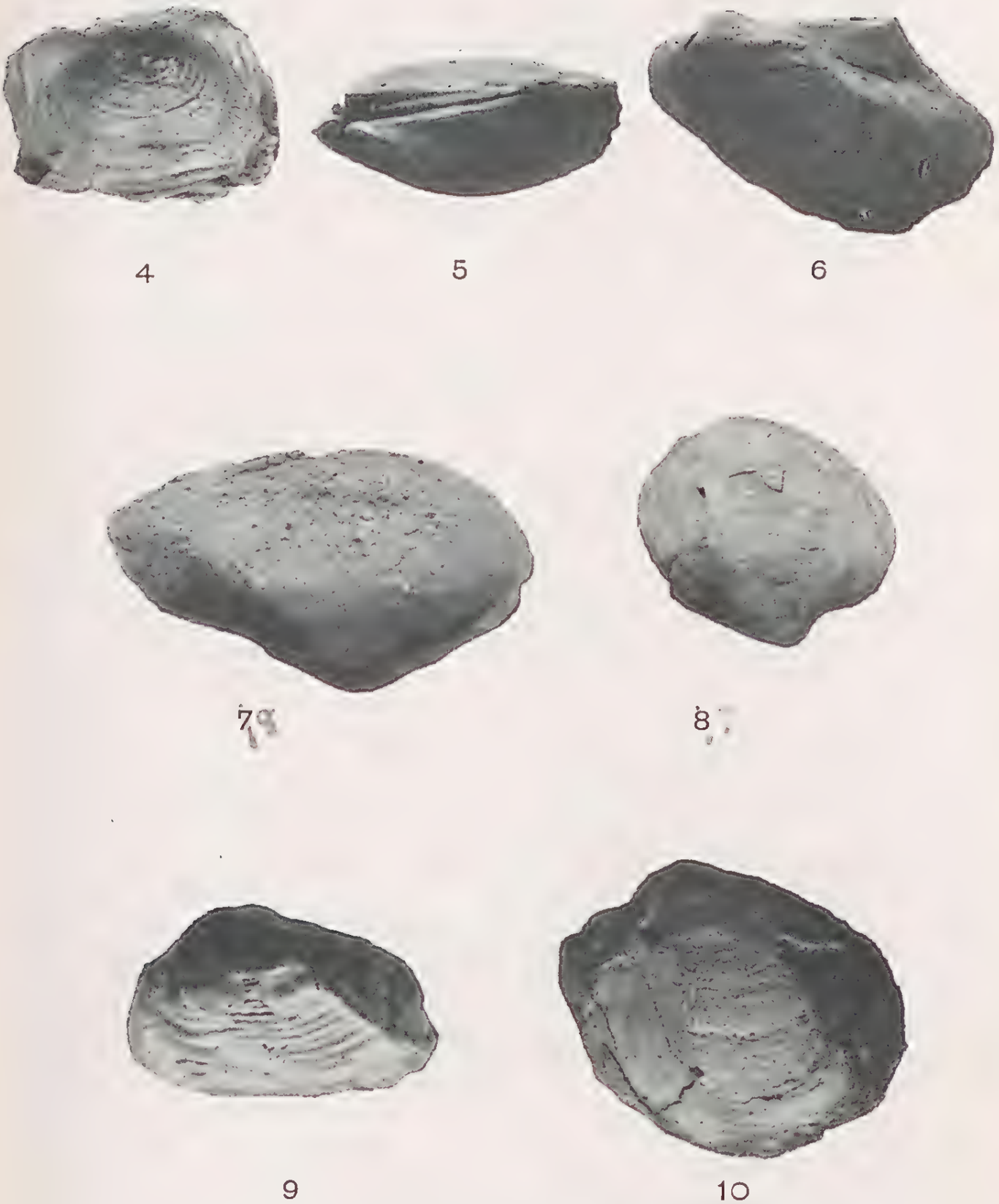

Fig. 37.—Typical Marine Fossils of the Bowen River Coalfield (Middle Bowen Marine Series).

4. *Productus farleyensis* (Eth. and Dun.), Black Gate, Blenheim.
5 and 6. *Merismopteria sp. nov.* (?), Corduroy Creek.
7. *Astartila* cf. *polita* (Dana), Coral Creek.
8. *Chænomya sp. nov.*, Corduroy Creek.
9. *Mæonia carinata* var. *minor* (Eth. fil.), Coral Creek.
10. *Astartila* cf. *transversa*, Corduroy Creek.

ranges of *Bellerophon* (*Warthia*) *micromphalus*, and *Merismopteria* extend from at least near the base of the Collinsville beds up to the Upper Bowen marine horizon. *Productus brachythærus* has a similar range. *Chænomya* as a genus is particularly characteristic of the Collinsville beds, and a new species as yet undescribed occurs in these at Corduroy Creek. *C. Etheridgei*, so abundant in the Upper Marine of New South Wales, has been found in the Collinsville beds at Carpet Snake Creek, and at the base of the Big Strophalosia horizon at the Emu Plains Crossing of the Bowen River. *Cleobis grandis*, of large size (up to 7 in. in length) has been found in Carpet Snake Creek and Corduroy Creek (Collinsville beds). The *Aviculopectens* as a group are abundant throughout the Series. *Mourlonia Strzeleckiana* is particularly abundant in the lower half of the Collinsville beds, but its range is extensive, as it extends up to the Upper Bowen marine horizon. *Spirifer* and *Martiniopsis* appear comparatively rare when compared to the abundance of the previously listed genera, and do not here occupy the same numerically important position that they do in the Upper Marine beds of New South Wales. *S. tasmaniensis* is the most common species amongst the Spirifers. *Spiriferina duodecimcostata* is recorded for the first time from this field, both from the Marine Series and the Upper Bowen. *Derbyia senilis* is of special interest in this field, as it has not yet been recorded elsewhere in Eastern Australia. Daintree* first recorded this species in Pelican Creek overlying a coal seam, which locality would place it at or near the base of the Marine Series. He remarked that it was common throughout all the "lower marine series." Of all the numerous marine sections examined during the recent fieldwork, the only occurrence of this fossil observed in the Marine Series was in one individual bed exposed at Coral Creek, near Sonoma, and in Pelican Creek. Jack originally recorded it from four localities; two of them (those mentioned above) are on the same horizon, and the whole four may be so. Specimens are represented in the Museum collection of the Queensland Geological Survey, collected by Blake and Graff from a new locality, which is somewhere in the northern portion of State Reserve No. 2. This locality should place *Derbyia* on a low horizon in the Collinsville beds. The Coral Creek bed is much higher in position than these, but the species also occurs in great abundance in the Upper Bowen marine horizon some thousands of feet probably above the top of the marine series. *Derbyia senilis*, therefore, apparently ranges at least from low down in the Middle Bowen to the Upper Bowen, but it does not appear so far to be present except in the several individual beds in which it has been noted. Corals are represented only by several poor specimens from Coral Creek, first identified by Dun as zaphrentoid corals. As Etheridge does not record any from the collections of Jack, these are possibly the first corals collected. The name, Coral Creek, is doubtless

* R. Daintree. Geol. of Queensland. Geol. Soc. London, vol. xxxiii., Part 3, 1872. pp. 287–288.

derived from the abundance of *Stenopora* occurring there. As the same fossils occur again and again at many different localities it is proposed to give here lists of fossils collected from the more important ones only, representing different horizons as far as possible.

Location.—Corduroy Creek, about ¼ mile south of railway line.

(*Horizon*, about 160 ft. above base of Collinsville Beds.)

Spiriferina duodecemicostata
Martiniopsis sp.
Aviculopecten tenuicollis
Astartila cf. transversa (Dana)
Chænomya sp. nov.
Stutchburia sp.
Merismopteria sp. nov.
Notomya (*?*)
Mytilus (*?*)
Cleobis (*?*)
Mourlonia Strzeleckiana
Bellerophon (*Warthia micromphalus*

Location.—Pelican Creek, near Pumping Station.

(*Horizon*, Big Strophalosia Bed—overlying 50 ft.)

Fenestella sp.
Strophalosia Clarkei
Productus brachythærus
Spirifer sp.
Mœonia sp. nov. (*?*)
Hyolithes sp.

Location.—Emu Plains Crossing of Bowen River, north bank of river, and ½ mile south of river.

(*Horizon*, top of basal beds to 600 ft. above.)

Stenopora Jackii
Productus brachythærus
Strophalosia Clarkei
Spirifer vespertilio
Aviculopecten sp.
Chænomya Etheridgei
Stutchburia sp.
Astartila sp.
Merismopteria macroptera
Cleobis sp.
Mourlonia Strzeleckiana
Bellerophon (*Warthia*) *micromphalus*

Location.—Sonoma, and Coral Creek in the vicinity.

(*Horizon*, 200 ft., inclusive, above the top of the Collinsville Beds.)

Zaphrentoid coral
Stenopora cf. ovata
Protoretepora sp.
Derbyia senilis
Strophalosia sp.
Spirifer tasmaniensis
Aviculopecten sp.
Mœonia carinata

Location.—Hazelwood Creek, 2¼ miles above Turner's.

(*Horizon*, near top of Marine Series.)

Crinoid stems
Fenestellid
Strophalosia Clarkei
Spirifer tasmaniensis
Productus brachythærus (*broad type*)
Martiniopsis subradiata
Dielasma hastata (*var.*)
Aviculopecten cf. Engelhardti
Cast of a gasteropod

Location.—½ mile east of Black Gate, Blenheim.

(*Horizon*, near top of Marine Series.)

Productus farleyensis (Eth. & Dun.)
Strophalosia Clarkei
Martiniopsis sp.

One mile east of Black Gate, in a prominent sandstone ridge apparently equivalent to a low horizon in the Collinsville beds, the pelechypods *Chænomya, Merismopteria,* &c., are found.

It will be noticed from the above lists that, the higher the horizon, the more numerous the brachiopods appear to become at

the expense of the pelechypods. It is the Collinsville beds which have particularly a wealth of pelechypods, but they also contain the prolific *Strophalosia* horizons. Contemporaneously with the remarkable development of the pelechypodan fauna in the Collinsville beds is the great abundance of glacial evidence.

Age of Marine Series.

This series is considered to be contemporaneous with the Upper Marine Series of New South Wales. The assemblage of fossils is not inconsistent with those in that series, but its main link is with the Branxton beds of the Upper Marine in the important glacial beds of Collinsville associated with an abundance of *Strophalosia, Chœnomya,* &c. Although the field has been now largely collected from by different workers, more particularly in the Collinsville area where there has been very extensive collecting, the characteristic fossil of the Lower Marine (N.S.W.) beds (*Eurydesma cordatum*) has not been found. It seems unlikely that any important horizon of this fossil could have remained undetected in the Collinsville district. Lying on this series are approximately 9,600 ft. of freshwater beds, containing numerous coal seams, which appear to correspond with the freshwater beds of the Tomago, Dempsey, and Newcastle Series.

THE UPPER BOWEN FORMATION.

This formation extends from Coral Creek south to, and beyond, the Leichhardt and Denham Ranges, and is identical with the "Lower Freshwater Series" of the Dawson and Mackenzie Rivers, as mapped by Cameron immediately south of the Bowen River watershed. The geological detail of the formation is not known to any great extent, and on the Bowen field will possibly be a matter of some difficulty to elucidate, as the greater part is covered with blacksoil plains and brigalow scrub. The estimate of approximate thickness—9,600 ft.—is considered reasonably reliable, as it represents the measurements along a traverse (from "Black Gate" thence along Sandy Creek to Redcliffe Range) in but slightly disturbed strata with gentle and uniform dips in one direction in which the marine beds are defined on one side and the Trias (?) sandstones on the other. Lithologically it consists chiefly of tuffaceous sandstones with coal and shales in a number of different localities which cannot yet be correlated with one another. The few details of coal occurrences that are available are given in the chapter on Coal Resources. The tuffaceous sandstones are distinct from other groups of sandstones on the field, and they are so abundant that they give a character to this formation which readily enables differentiation in the field from the rocks and soils of the other formations. The soils—rich, dark, calcareous loams—derived from this rock constitute possibly some of the most fertile plains in Queensland. Sandy soils alternate with these to a minor extent. Fine mud shales, greenish in

[*Photos., Sanderson.*

Fig. 38.—Typical Marine Fossils of the Bowen River Coalfield (Middle Bowen Marine Series).

11. *Mourlonia Strzeleckiana* (Morris), Corduroy Creek.
12. *Bellerophon* (*Warthia*) *micromphalus* (Morris).
13. *Cleobis grandis* (Dana), Corduroy Creek.

colour but often ferruginous from weathering, are noticeable at Jack's Creek (near the road crossing) and Stoney Creek south of Havilah. These contain abundant specimens of *Glossopteris*. Fine-grained yellow and grey calcareous sandstones and bands of cone-in-cone limestone, both recalling those typical Walloon (Jurassic) rock types, were noted in this formation south of Stoney Creek and about 5 miles south of Byerwin. Several flows of contemporaneous basalt in the southern portion of the field and volcanic tuffs immediately south of Turner's residence, Hazlewood Creek, and in the creek at Byerwin Homestead, were also noted in the rapid traverses across this formation. Only one conglomerate bed was observed

Fig. 39.—Tuffs and Sandstones of Upper Bowen Formation at Byerwin Homestead.

in all the sections seen. This synopsis indicates the general lithological character of the strata. The prevailing tuffaceous sandstone is almost universally of a peculiar dirty yellowish-green colour, becoming dark on weathering, and outcrops are frequently almost black. It is of moderately coarse grain. It resembles no other rock type observed in any of the other formations on the field. The occasional sandy soils are doubtless derived from interbedded siliceous sandstones. The formation is extensively intruded by volcanic sills over almost the whole of the area, particularly at Havilah and Blenheim Creek. It is much less intruded south of a line joining Blenheim and Byerwin. The geological features of greatest interest in this very thick formation are the unusual fossil tree horizons and the marine horizon.

Jack* mentions fossil trees at ¼-mile west of Rosella Creek on the Havilah-Birralee road, and also near Jack's Creek, from

* R. L. Jack, Geol. and Pal. of Queensland. Q.G.S. Pub. 92, p. 165.

which he cited an instance of a tree measuring 31 ft. long and up to 12 in. in diameter. Also between Walker's Creek and Bee Creek, in the Nebo district, the Upper Bowen beds there contained so many silicified logs that Jack wrote: "One might imagine a forest to have been felled on the spot and subsequently petrified."* The Lands Department 4-mile map of the Bowen River area shows near Byerwin a notation of "petrified forest." They are sufficiently remarkable to have attracted the attention of residents of the district. The trees are composed of either black, flint-like silica, or of ironstone. A very well-marked horizon crosses Sandy Creek about 1 mile above its mouth and continues almost to Hazelwood Creek, being observable on the main road near the Blenheim boundary fence. Large trees embedded in tuffaceous sandstone were observed in a small western branch of Cockatoo Creek within several hundred yards of the pump (watering place for cattle). There are certainly a number of different horizons, and the more important of these will probably have a future stratigraphical value as index beds. The Collinsville coal measures do not contain these "tree" horizons, and with the exception of their basal beds, fossil wood is comparatively rare in them.

The Marine Horizon.

Its stratigraphical position is uncertain, the beds in Rosella Creek associated with it showing variation from the ordered regularity of strike and dip which obtains over the greater part of the field. It is probably to be placed below the middle of the Upper Bowen. Jack noted the geographical position of this bed at two spots close together—viz., in Rosella Creek, 2 miles above Havilah paddock, and on the Havilah-Byerwin road, 1 mile south of Rosella Creek Crossing. It has now been found 2 miles further south, but efforts to locate it in other portions of the field, particularly on the eastern side where dips are steeper and the strata are better exposed, have failed. On the east side of the Havilah-Byerwin road about 1 mile east of Bald Hill, a low sandstone ridge rises about 40 ft. above the surrounding fertile blacksoil plains. It is composed of intensely hard sandstones yielding a sterile soil so that it attracts notice from a distance. These beds are those of the marine horizon and they yielded numerous specimens of *Derbyia senilis* and impressions of *Stenopora;* they dip at 5° towards east by north. The ridge quickly disappears beneath blacksoil plains, to the south, which extend for some miles and hide all rock outcrops. The bed at this spot is probably 50 ft. to 60 ft. thick. At the Rosella Creek crossing are numerous boulders of the typical brown calcareous sandstone matrix of *Derbyia* crowded with fossils. These have certainly come from the outcrop in the creek described by Jack. Etheridge has recorded three forms from Jack's collection from this horizon—viz., *Derbyia senilis, Productus brachythærus,* and *Goniatites sp. ind.* To these can now

* R.L.J. *Op. cit,* p. 168.

be added the following forms recently collected from the sandstone beds and the creek boulders:—

Stenopora sp.	*Merismopteria sp.*
Fenestellid	*Aviculopecten sp.*
Spirifer sp.	*Mourlonia Strzeleckiana*
Spiriferina duodecimcostata	*Bellerophon micromphalus*

The outcrop of the marine horizon on the ridge described is so conspicuous that from its non-discovery elsewhere it is considered unlikely that it attains any important thickness on the Bowen field.

Upper Bowen Fossil Flora.

There are many horizons in which an abundance of *Glossopteris* has been noted. Jack collected many specimens, later examined by Etheridge* and Walkom.† In Walkom's table III. (page 43) of Upper Bowen Formation fossil localities, not one is cited from the Bowen River Coalfield. Three localities from that field, included in the Lower Bowen Series—table II.—viz., Cockatoo Creek, Macarthur's Creek, and Rosella Creek, have their entire courses within the Upper Bowen Formation as mapped by Jack and followed in this report. The Lower Bowen, as defined by Jack in the type district, is 6,000 ft. below the base of the Upper Bowen. This regrettable confusion of horizons, which appears to have arisen from the application of the provisional classification of the Dawson and Mackenzie Permo-Carboniferous Coal Measures to the Bowen River Coalfield, has led Walkom to comment on the decline of the flora in the Upper Bowen, during which he naturally concluded the number of specimens was notably less than in the Lower Bowen. It is probably quite the reverse on this coalfield; the Upper contains much more evidence of an exceedingly abundant flora and probably a greater number of species. The fossil tree horizons also are characteristic of the Upper and unknown in the Lower and Middle Formations, except for some sections of fossil tree trunks in the basal beds of the Collinsville Coal Measures.

Transferring the horizons mentioned above to the Upper Bowen, we have the following species as listed by Walkom:—

Cockatoo Creek.

Phyllotheca australis	*Glossopteris Browniana*
Phyllotheca sp.	*Glossopteris indica*

McArthur's Creek.

Glossopteris Browniana

Rosella Creek.

Glossopteris tortuosa	*Dadoxylon Arberi*

Etheridge also describes *Sphenopteris lobifolia* from Rosella Creek (marine horizon), Upper Bowen Formation.

In addition to many specimens of *Glossopteris* collected by the writer at Blenheim, Jack's Creek, and Stoney Creek was one

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* Q.G.S. Pub. 92.

† Q.G.S. Pub. 270.

specimen of *Cladophlebis Roylei* found at Stoney Creek. Walkom records this species as from the Lower Bowen at Dawson, Bee Creek (Nebo), and from the Upper Bowen at Bonnie Doon (Clermont). Bee Creek has, however, been mapped as Upper Bowen by Jack, and its position in that is confirmed by the combined mapping of Cameron and the writer as well as supported by the occurrence of a fossil tree horizon in that locality. Although not apparently abundant, the distribution of *Cladophlebis** in the Upper Bowen seems widespread, and indicates possibly the approaching development of the succeeding Mesozoic flora.

CARBOROUGH SERIES (TRIAS?).

This series of tableland sandstones covers the axial line of the syncline in the southern half of the area mapped. It extends from Mount Leslie, an outlier, to the Leichhardt Range, a distance of 30 miles with only one break. It is then cut through by Suttor Creek, and the same sandstone formation starts again after a gap of 6 miles, to the south of which it has been mapped by Cameron for many miles along the Leichhardt and Carborough Ranges as Desert Sandstone of Upper Cretaceous Age.

The Redcliffe Range or Tableland is a partially dissected sandstone plateau about 7 miles across at its greatest width. It rises about 700 ft. to 900 ft. above the level of the surrounding country, which is occupied by the Upper Bowen Series, and is estimated to reach a height of about 2,000 ft. to 2,200 ft. above sea-level. It is capped by several hundred feet of buff-coloured to red sandstones forming more or less perpendicular cliffs—hence its name. It recalls strongly the Hawkesbury sandstone type of scenery and topography in the Blue Mountains of New South Wales, differing however in its much deeper colouring.

The thickness of sandstone is probably about 700 ft., but the lower beds contain interbedded clayshales. The sandstones are essentially siliceous and ferruginous and are distinct types from the Upper Bowen Sandstones. Jack described the formation as consisting of rigidly horizontal beds of possibly Cretaceous Age, lying unconformably on the upturned edges of the coal measures. He apparently only examined this formation from the north-west (Havilah) end, and I am in disagreement, after completely encircling the tableland, as to the angular unconformity stated by him to exist between this series and the Upper Bowen Formation. On the east side of the range throughout its length there is a general dip of about 5° westerly, agreeing closely with that of the underlying measures. The section was closely examined at the head of Sandy Creek. On the western side of the range where the Upper Bowen beds have

* Specimens of *Cladophlebis sp.* have since (September 1924) been found by the writer most abundantly with *Glossopteris* in what are mapped as the Lower Freshwater beds of the Dawson River, one mile west of Castle Creek Township, on horizons probably 1,000 ft. to 2,000 ft. above the top of the Marine Series there.

a gentle reverse dip the Redcliffe sandstones were also found to have reversed at angles ranging up to 10°, to the south of Byerwin. Even the sandstones of Mount Leslie have a slight north-easterly dip (5°?) at its northern extremity.

No fossil evidence of the age of the beds was obtained, and the Triassic Age of these is merely suggested by analogy with three somewhat similar sections in North Queensland where up to 800 ft. of nearly horizontal sandstones, &c., forming cliffs, overlie coal seams and measures containing the *Glossopteris* flora. These are Mount Mulligan described by Ball,* and Bett's Creek,† and Oxley Creek‡ (or White Mountain) described by the writer. At Mount Mulligan, Ball shows there is a slight unconformity between 700-800 ft. of conglomerates, sandstones, and shales, overlying the *Glossopteris*-bearing coal measures. The latter beds do not appear to be tuffaceous as are those on the Bowen River field; the overlying beds form the same cliff-like topography as at Redcliffe. At Bett's Creek a slight angular unconformity is shown between the Permo-Carboniferous coal measures and overlying coarse yellow sandstones forming cliff faces 200-300 ft. in height, which were qualitatively placed in the Desert Sandstone formation. At Oxley Creek is a rather similar section, the coal measures there also containing *Glossopteris* and underlying 300-400 ft. of white to yellowish sandstones which form almost vertical cliffs. These appear to be quite conformable, but three miles away a strong local unconformity was observed. There appears to be a strong lithological similarity between these four sandstone series all found directly overlying *Glossopteris*-bearing beds, and their correlation is suggested tentatively. A doubtful *Tæniopteris* was found at Bett's Creek in the Mesozoic beds, but at Mount Mulligan, Ball records in his second report, the occurrence of *Tæniopteris, Odontopteris, Phyllotheca* and *Gingko,* an assemblage which is much more characteristic of the Triassic in Queensland than of any of the Upper Mesozoic formations. On the probability of the relationship of these beds being established in the future, the Redcliffe Plateau is tentatively placed as of Triassic age since the Mount Mulligan series appear on fossil evidence to be of that age.

Sandstones forming prominent cliffs like those at Redcliffe, except as to colour, were recently observed to overlie the upper *Glossopteris* beds of the Upper Dawson River 10 miles west of Cracow. They are definitely as old as Lower Mesozoic (?=Ipswich Series) because they underlie conformably the Bundanba Series and the Walloon Coal Measures in the Taroom district.

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* L. C. Ball. Mount Mulligan Coalfield—Q.G.S. Pub. 237 (1912), and "Queensland Government Mining Journal," vol. xviii., p. 444 (September 1917).

† J. H. Reid. *Glossopteris* Beds of Bett's Creek—Q.G.S. Pub. 254 (1916).

‡ J. H. Reid. Coal Measures at Oxley Creek—Q.G.S. Pub. 258 (1918).

TERTIARY BEDS.

The age of certain limited areas of sandstone, &c., adjacent to the Leichhardt Range, where the Bowen-Mount Coolon road crosses it, has been established as Tertiary by fossil leaves. The Leichhardt Range in this locality is only slightly perceptible from a distance, and has an elevation of 1,400 ft. to 1,600 ft. above sea-level. About half-a-dozen low-set mesas are observable, several of which were found to consist of nearly horizonal coarse sandstones, grits, &c., covered with lateritic material, including clay-iron nodules, supporting thickets of lancewood. The gullies through these reveal sections of unbedded sediments, gravel cements, and masses of intensely hard "billy" and common opal. White quartz grits, sandstones, and pebbly conglomerates occur and appear to have roughly defined bedding planes indicated

Fig. 40.—Basalt Cone near Stoney Creek—Upper Bowen Formation in Foreground.

by slight dip slopes. These are all of distinct type from any of the Permo-Carboniferous strata examined. Between Cockatoo Creek and Parrot Creek, a hill rising 200 ft. above its surroundings (Mount Sambo?), furnished coarse sandstones underlain by diatomaceous shales in which were found impressions of dicotyledonous leaves. There appears to be a distinct angle of bedding between that of the more or less horizontal Tertiary sandstones and the Upper Bowen strata beneath which dips east at 7°. Andesite was found lying under the shales of Mount Sambo (?) and trachyte under one of the mesas near the road on the Suttor-Bowen divide. They appear to lie horizontally, and are probably Tertiary volcanic flows.

Mention may be made here of a number of isolated basalt pinnacles and hills, about twelve in number, arranged around Mount Razorback and Stoney Creek, within 3 miles on either side of the Mount Coolon road. They can scarcely be residuals of basalt flows, although some of the basalts are columnar. The most probable theory is that they are individual pipes. No basalt flows were observed in any part of the field of post-Permo-Carboniferous age, but they occur in the adjoining Isaacs River

basin. It may be surmised that these basalt pinnacles are of Tertiary age, in keeping with the age of the great basaltic flows throughout the State, and that they are a number of the foci from which similar flows have been derived and since removed by erosion.

IGNEOUS INTRUSIONS.

There are no large masses of igneous rocks on the field, but as sills, and occasionally as dykes, igneous rocks are of frequent occurrence throughout three-fourths of its area. In the southern portion, south of Byerwin and Blenheim Homesteads, they practically disappear, as far as surface evidence shows, and along Suttor Creek, near Mount Hillalong, no evidence was seen of them. The area south of the Bowen River field will therefore on this account probably be more favourable for the development of the coal seams in the Upper Bowen Formation in the future. Both the Middle and Upper Bowen Series and some of the Lower Bowen sandstones have been found to be intruded by sills. In the Blenheim district intrusions have been of exceptional severity along the Bowen River south of Sandy Creek and in Blenheim Creek. In the latter there are areas in which all the shales and sandstones are glazed, evidently by silicification resulting from heat and vapours given off by intrusions. Sills were observed in the vicinity of Emu Plains Crossing, right along Jack's Creek and McArthur's Creek, Coral Creek (in the Upper Coal Measures) and to the north-west and west of the Bowen Consolidated Mine, near Collinsville. On the western side of the field there are the basalt pinnacles around Mount Razorback, north of Byerwin, an unusual lamprophyre sill at Stoney Creek crossing, the sills proved in boring at Havilah and the sills in the Lower Bowen sandstones at the Bowen River crossing at Strathbowen. These occurrences indicate that not many portions of the field of any considerable size are free from intrusion to some degree. As a general rule, the intrusive rocks are of intermediate to basic composition and consist mostly of porphyrites, andesites, and dolerites. Some of the larger sills, in hand specimens, are like fine-grained diorites in composition and texture. In the Collinsville Coal Measures the sills have usually followed the coal seams to a much greater extent than the other strata, as indicated in the bore records, but there are several notable exceptions to this propensity. The drill records also show that areas in which there is no surface evidence of intrusive sills may be intruded below, involving the destruction of coal seams. The Collinsville area is a case in point. Sills occur up to 50 ft. to 60 ft. thick as indicated in bores at Havilah and in Bores Nos. 3 and 14, near Collinsville.

The prevalence of intrusions in this field is going to undoubtedly prove a serious drawback and expense to the development of the coal seams throughout a great area of this large coalfield in future generations. For the present there are very large coal reserves near Collinsville where portion of the seams have escaped this menace, although this area, too, shows the presence of intrusive rocks.

CORRELATION OF THE BOWEN FORMATIONS.

Perhaps the most helpful geological data of the Permo-Carboniferous rocks of Central Queensland, in facilitating a satisfactory and rather complete correlation of them with those of the New South Wales Permo-Carboniferous system, have been the discovery of marine fossil beds of that age interbedded in the volcanic rocks of Tooloombah (The Styx), and the determining of the section containing the Wilangi (The Styx) fossil beds of Rands* as interstratified with the lower volcanic rocks. Both of these can, on the past mapping of Jack, Gibb Maitland, and Dunstan, be definitely linked up in the field with the Lower Bowen volcanics which on the Bowen River itself do not appear to contain marine beds. Since the base of the Bowen River marine beds at Collinsville is 700 ft. above the top of the volcanics, with coal measures intervening, this data has made quite clear the fact that there are at least two distinct marine series in Central Queensland (apart from several other relatively unimportant marine horizons) separated in certain areas by a highly productive coal series which thus agrees broadly in succession with the principal Permo-Carboniferous basin of New South Wales.

(A) WITH THE HUNTER RIVER AREA (N.S.W.).

The Permo-Carboniferous stratigraphy of this region by Professor Sir Edgeworth David† represents the most complete section of these rocks yet described in Australia. It is now possible to attempt in some detail the correlation of the Bowen River portion of the large Central Queensland Permo-Carboniferous basin with this section.

This correlation, set out in the Table 2, is based on (1) the sequence of marine beds and freshwater beds, including coal measures; (2) palæontological evidence; (3) occurrence of glacial beds; and (4) evidence of contemporaneous vulcanicity.

The Hunter River section is considered to contain a maximum thickness of 16,400 ft., the Bowen River section approximately a maximum of about 18,000 ft. The thicknesses of the Middle Bowen Coal Measures (700 ft.) and Marine Series (2,400 ft.) are tendered as approximately accurate for the Collinsville area; that of the Upper Bowen (9,600 ft.) as likely to be an approximately accurate estimate; that of the Lower Bowen (5,400 ft. ?) as an estimate subject to revision owing to the

* This locality is given as Selection 88, near the foot of Connors Range. *See* p. 9, Q.G.S. Pub. 84.

† Professor Sir T. W. E. David, F.R.S. Geology of the Hunter River Coal Measures, N.S.W. Memoir (Geol. No. 4), N.S.W. Geol. Survey, 1907.

uncertainty of the thickness of its lowest subdivision. It has been pointed out that there is only one important Marine Series occurring on the Bowen River field, although there have been two slight marine transgressions in addition, one about 250 ft. to 300 ft. below the base of the Marine Series, the other in an uncertain position in the Upper Bowen Series. The Marine Series is taken as a starting point for comparison with the Hunter River section. It is obviously, from its marine fossils and glacial evidence, to be connected with either the Upper or Lower Marine Series of the Hunter River. If it be referred to the Lower Marine the two sections are thrown out of all relative proportion, and it would then be necessary to account for probably over 6,000 ft. of Permo-Carboniferous sediments (including two distinct coal measures) fragmental volcanics and lavas below the base of the Lower Marine Series. If, on the other hand, we refer it to the Upper Marine of the Hunter River we have a sequence and a proportion between the accompanying formations in each area that agree unusually well in many respects, considering the relative geographical positions of the two fields.

In a broad survey of the two series in the table it will be seen that there are corresponding coal-formation periods in each as well as one corresponding marine-glacial period, and that at the top of each are great thicknesses of freshwater sediments with coals, while both of these may have siliceous sandstone cappings of "Hawkesbury" type overlying them with little or no angular unconformity in bedding planes.

The Lower Bowen Formation, on the type field, contains coal measures (Mount Devlin) at the approximate horizon of Garrett's seam on the Hunter River field (i.e., 3,000 ft. above its base), and sandstones either in them, or on an approximate horizon, contain *Glossopteris*. Marine beds have not, so far, been found in the formation on this field, though they may possibly be in the future. In the Mackay and Styx districts the Lower Bowen beds are at least partially fossiliferous marine sediments* though still mainly volcanic. The marine fossils from other localities in the Lower Bowen Formation include:—

Tooloombah (The Styx).†

Eurydesma cordatum var. *ovale* (Eth. fil. & Dun)	*Martiniopsis* cf. *oviformis* (McCoy)
Strophalosia sp.	*M. subradiata* var. *branxtonensis* (Eth. fil.)

† List identified by Dr. F. W. Whitehouse.

Wilangi (The Styx).‡

Eurydesma cordatum	*P. subquadratus*
Aviculopecten squamuliferus	*Spirifera Strzeleckii*
Deltopecten limæformis	*Agathiceras sp.*
Productus brachythærus	

‡ List of fossils from Queensland Geological Survey Register.

Thus we see in this formation in Central Queensland evidence of both freshwater and marine sedimentation, a condition reproduced in the Lower Marine of the Hunter River.

* J. H. Reid. Permo-Carb. Geology of Queensland, Additional Notes "Queensland Government Mining Journal," February 1924.

Table 2.—Correlation of Bowen River and Hunter River (N.S.W.) Coalfield Formations.

Bowen River Coalfield (Q.)		Hunter River Coalfield (N.S.W.).	
The Upper Bowen is overlain conformably by about 600 ft. of Trias (?) sandstones. ("Hawkesbury type") = Carborough series.		*The Newcastle Coal Measures are overlain by Narrabeen beds or Hawkesbury sandstones, sometimes conformably.*	
UPPER BOWEN (9,600 ft.)	9,600 ft. of freshwater sediments with *Glossopteris*, *Cladophlebis*, &c., highly tuffaceous with a few basic lava flows and a number of undifferentiated coal measures, also one marine horizon. Fossil tree horizons abundant	NEWCASTLE COAL MEASURES, DEMPSEY BEDS, TOMAGO COAL MEASURES (Total 4,900 ft.)	4,900 ft. of freshwater sediments with two defined series of coal measures, also tuffaceous shales and thin coals in the Dempsey beds. Fossil tree horizons in Newcastle Coal Measures
MIDDLE BOWEN (3,100 ft.)	**Marine Series** (2,400 ft.) sandstones, mudstones, and shales with important glacial epoch, type fossils *Strophalosia*, *Productus*, *Chœnomya*, &c.	UPPER MARINE SERIES (6,400 ft.)	Marine sediments, including Branxton glacial beds, *Chœnomya*, *Crinoids*, *Strophalosia*, &c.
	Collinsville Coal Measures (700 ft.) *Glossopteris*, *Nœggerathiopsis*, &c.	GRETA COAL MEASURES (130 ft.–200 ft.)	*Gangamopteris*, *Glossopteris*, *Nœggerathiopis*
LOWER BOWEN (5,400 ft. ?)	**Mount Devlin Volcanics** (2,000 ft.) mainly porphyrites, basalts, tuffs, agglomerates, rhyolites, &c.	LOWER MARINE SERIES (4,800 ft.)	Marine sediments and tuffs, &c., *Gangamopteris* beds, coal seam, volcanic belt, glacial beds
	Mount Devlin Coal Measures (400 ft.) *Glossopteris* on this or an approximate horizon		
	Mount Toussaint Volcanics with interbedded sandstones, tuffs, &c. (3,000 ft.?)		
Total thickness of section, 18,100 (?) ft.		*Total thickness of section, 16,300 ft.*	

The Lower Bowen, however, is essentially a volcanic formation—largely basic and intermediate types—and as such covers undoubtedly a great part of Central Queensland. Volcanics are not unimportant in the Lower Marine Series either, for, in addition to a number of basalt (natrolite) flows, David shows that there are considerable thicknesses of andesitic tuffs, tuffaceous shales, &c. It is perhaps a connecting link that amygdaloidal and zeolitic basalts are a feature of both fields. While there is a well-defined glacial horizon in the Lower Marine, a corresponding one has not been proved in the Lower Bowen so far in this district. Mention, however, should be made of a boulder bed near Mica Creek on the Collinsville railway at the 43-mile peg. No other rocks are exposed in contact with this bed, and it shows no trace of bedding. The suggestion that it may possibly be a glacial till lies in the fact that it mainly consists of worn granite boulders, and a basic dyke cutting through it shows that it is not of recent age. If it is bedded with the Mount Toussaint volcanics—a point that is not certain—its horizon would probably be about 1,700 ft. below the base of the Mount Devlin Coal Measures.

The Collinsville Coal Measures contain much the most important seams yet discovered. The Bowen and Blake Seams occasionally each exceed 20 ft. in total thickness. The aggregate thickness of coal in the series is usually from 45 ft. to 60 ft. in the Collinsville area. The accompanying strata are essentially siliceous grits and sandstones, also some soft basal conglomerates of volcanic material. The shales have been found to contain *Glossopteris* and *Nœggerathiopsis*, but *Gangamopteris* has not yet been recorded. The Greta Measures contain up to 44 ft. of coal, and are characterised by a *Gangamopteris-Glossopteris* flora.

The Marine Series of the Middle Bowen is considered to be 2,400 ft. thick just north of the Bowen River, but decreases to about 1,600 ft. at Collinsville owing to progressive overlap of the lower beds. It is almost certain, as this is the extreme top of the Permo-Carboniferous basin, that the series increases much in thickness to the south, and that therefore the Bowen River figures do not represent the maximum thickness of the series in Central Queensland. This can reasonably explain the disparity between the thickness of 2,400 ft. given and the maximum thickness of 6,400 ft. of the Upper Marine Series. Sandstones, shales, and mudstones are characteristic generally of both. The most striking feature in common are the important glacial beds in each instance characterised by a great development of *Strophalosia Clarkei*. In the Middle Bowen glacial strata there is a remarkable 93-ft. bed of *S. Clarkei*, and both above and below this are additional beds of the same fossil. The substance of the shell of *Strophalosia* is invariably preserved and the big bed makes a whitish outcrop very easy to follow. The glacial epoch represents a thickness of perhaps 1,000 ft. to 1,200 ft. sedimentation on the Bowen River field, starting immediately above the 800 ft. of basal sandstones, and

thus appears to show evidence of duration over a longer period than shown in the Branxton glacial beds. The characteristic *Trachypora* horizon of the Upper Marine has not been found on the Bowen River field. Corals are poorly represented, but a few specimens of a zaphrentoid coral have been found in the mudstones of Coral Creek, i.e., near the top of the glacial beds.

The assemblage of fossils as a whole resembles the Upper Marine fauna of New South Wales. Comparing the forms found with the list of fossils from the Upper Marine of the Southern District (N.S.W.), quoted by Harper,* there appears to be a great resemblance. The following forms are very abundant and characteristic of the Middle Bowen Marine Series:—*Cleobis grandis, Chanomya Etheridgei, Martiniopsis subradiata, Merismopteria* (several species), *Mœonia carinata, Astartila sp. Aviculopecten sp., Mourlonia Strzeleckiana, Agathiceras micromphalus, Productus brachythærus, Strophalosia Clarkei, Fenestellidæ, Stenopora* (several species), &c.

The Upper Bowen has a thickness of over 9,000 ft. which is apparently all of freshwater origin with the exception of the marine horizon, which contains a fauna comparable to that of the Middle Bowen Marine Series. There are numerous occurrences of coal in this formation, of similar composition to that of the Collinsville coals, but their horizons have not yet been differentiated. The Daintree Seam of Jack, at the base of it, probably corresponds with the position of some of the Tomago coals. There is also evidence of coals on progressively higher horizons at Havilah and Jack's Creeks, also at Byerwin. *Glossopteris* is very abundant throughout the whole formation, and *Cladophlebis Roylei* has been recorded from several localities as isolated specimens. Jensen records the occurrence of *Gangamopteris cyclopteroides* in what is the Upper Bowen Formation in Jack's classification.† The sandstones of the Upper Bowen are commonly tuffaceous, and there are occasional flows of basalt interbedded. There does not appear on the whole to be a close resemblance, lithologically, between these beds and the higher groups of freshwater beds in the Hunter River district comprising the Tomago Coal Measures, the Dempsey beds, and the Newcastle Coal Measures. The great thickness of freshwater sediments in each case overlying a thick marine series, however, suggests uniformity of physical conditions during deposition and some time relationship. David shows also that the Newcastle and the Dempsey beds are in part tuffaceous. Another resemblance is that portions of both these groups are characterised by remarkable fossil tree horizons. On the Bowen River field this is a notable feature confined almost entirely to the Upper Bowen Formation.

* L. F. Harper. Geology of the Southern Coalfield. Memoir (Geol.) No. 7, N.S.W. Geol. Sur.

† H. I. Jensen. Proc. Linn. Soc. N.S.W., vol. xlviii., pt. 2.

(B) WITH CENTRAL QUEENSLAND AREAS.

Probably no other Permo-Carboniferous areas in Queensland offer such advantages as the Bowen River Coalfield for studying the sequence and stratigraphical details of the formations of that period. This is due mainly to the fact that it lies at the northern apex of a vast Permo-Carboniferous area (which extends unbroken to almost as far as Taroom on the Upper Dawson, a distance of 400 miles to the south-south-east) and that a thickness of about 18,000 ft. of conformable strata, ranging from the Lower Permo-Carboniferous into probably the Mesozoic, can be observed in but slightly disturbed country at the north end and western side of the field. These beds are thus in proximity to the much disturbed line along the eastern boundary, where the Lower Bowen rocks are more or less altered, rendering the correlation of the same rocks in the disturbed and undisturbed areas practicable.

Fig. 41.—View of Bowen River, One Mile below Emu Plains Crossing.

The absence of these field advantages would appear to have been a drawback in the areas further south, for the Permo-Carboniferous rocks there still dip rather steeply, in a general westerly direction, along the inland side of the Coastal Range, but the basin has widened up to 150 miles and the Permo-Carboniferous rocks to the west are, to a great extent, covered by more recent deposits, and the easy comparisons possible on the Bowen River are apparently impossible further south.

All the geological work done on this very large Permo-Carboniferous basin is, as yet, more or less reconnaissance work and there is no detailed work except in isolated instances referring to small areas. This applies still to the greater part of the Bowen field, but the northern portion of it has now been worked out in considerable geological detail. It would, therefore, appear advisable to still consider the Bowen River district as the

type area of the Permo-Carboniferous in Queensland with which correlation of other areas might be made.

An examination of the literature on the area south of the Bowen shows that it is most probable, amounting practically to a certainty, that the Lower Bowen Formation extends right along the eastern side of the inland Permo-Carboniferous basin, i.e., to the west of the Coastal Ranges (Connor, Boomer Ranges, &c.) although it is not mapped as such but as "Gympie" or something older. This is no doubt partly to be accounted for by the older appearance of the Lower Bowen rocks where they have been folded, and to the fact that they are to some extent metalliferous. As Jack, at the "Wall Sandstone" on the Bowen River (Emu Plains Crossing), appears to have included rhyolites, tuffs, and coal measures in the "Metamorphic Series," although conformably dipping with the Marine Series, their almost certain occurrence and apparent non-recognition as the Lower Bowen right down to the Dawson need not occasion surprise. Recent fieldwork* has indicated that large areas of the "Gympie" formation as they appear on various Geological Survey maps are to be correlated with the Lower Bowen, e.g., Tooloombah in the Styx district, and perhaps the Collaroy district.

A recent visit (September 1924) to the proposed dam site on the Dawson River gave an opportunity for a sectional examination of the Permo-Carboniferous rocks occurring in the vicinity of Delusion Creek (Upper Dawson). The same stratigraphical sequence, with the exception of the apparent omission of the Collinsville Coal Measures, was observed there as is found on the Bowen River—viz., andesitic and basaltic lavas, a Marine Series (including some contemporaneous volcanics) overlying the lavas, a freshwater (*Glossopteris*) series overlying the Marine Series and in turn overlaid by siliceous sandstones (Hawkesbury type). In this district the latter definitely underlie the Walloon (Jurassic) and Bundanba beds to the east of Taroom, and are thus probably to be correlated in some degree with the Ipswich Series of Triassic age, this being supported by the occurrence of *Cladophlebis australis* in them.

The broad sequence in the southern extremity of the Permo-Carboniferous basin appears therefore almost identical with that of the Bowen River. Further the rocks are found to strike and dip rather uniformly in both areas as both have steep dips on the eastern margin, flattening to very low angles followed west.

The Dawson-Mackenzie Area.

The Dawson-Mackenzie River basin, described by Mr. Dunstan,† is separated from the Bowen River field by a distance of 120 miles. The two fields have been classified in different terms, but there is now no doubt as to the identity of some, if

* J. H. Reid. *Op. cit.*

† B. Dunstan. Q.G.S. Pub. 155. Brisbane, 1901.

not all, of the formations in them. The Dawson River classification was stated to be "provisional only, its final adoption depending on future work in the intervening areas." It cannot, however, be supported as a suitable classification for the Permo-Carboniferous rocks of the Bowen River, or the coastal areas of these between Proserpine and The Styx. The intervening 120 miles was subsequently covered by Cameron's geological sketch map* based on reconnaisance work only and not showing any stratigraphical sections or details beyond certain geological boundary lines. The Dawson-Mackenzie classification was adopted in it presumably because fieldwork started at the Mackenzie River and finished at Mount Britton, which left a considerable gap between that locality and the area mapped by Jack, although Gibb Maitland had previously shown the continuity of the Mount Britton marine beds with the Bowen Marine Series of Jack's correlation, which continuity is confirmed by the recent fieldwork of the writer. Cameron shows the Mount Britton beds ("Lower Marine") underlying the continuation northwards of the Lower Freshwater Series of the Dawson. The latter, however (at Bee Creek, Walker's Creek, &c.), were formerly described as Upper Bowen by Jack and Gibb Maitland, a correlation which can also be confirmed as a result of traversing the continuation of the Upper Bowen formation into the northern area mapped by Cameron where it is shown as the Lower Freshwater Series in the vicinity of Mount Hillalong. About 60 miles south-east of Mount Britton, Cameron mapped further marine beds, near Yatton. These he shows as the continuation of the Mount Britton marine beds (= Middle Bowen) as they would undoubtedly appear to be. There is also, however, a *Eurydesma cordatum* horizon in marine beds, near Yatton, suggesting a repetition of the Lower Bowen marine beds of Wilangi (20 miles further east) and Tooloombah, and the reconnaisance work of Cameron at that period could scarcely take into account the probability of two distinct marine Permo-Carboniferous Series, with possibly only a slight stratigraphical interval, occurring close together. However, such a section occurs in the Tooloombah-Styx section on the east side of Connor Range,† and is to be expected at Yatton where the beds have reverse dips. Using Cameron's mapping, in conjunction with the writer's, the "Lower Marine" in the Dawson-Mackenzie area is identical in part at least with that of the Middle Bowen Marine Series (= Upper Marine of N.S.W.), and the Lower Freshwater Series, as mapped by Cameron between Mount Britton and the Leichhardt Range to the west of it, equals the Upper Bowen Formation. This appears to be further supported by descriptions of the Dawson "Lower Marine" beds, the marine fossil assemblage in them, as well as by the description and stratigraphical relationship of the "Gympie" Formation on the Dawson River.

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* W. E. Cameron. Q.G.S. Pub. 200. Brisbane, 1905.

† J. H. Reid. *Op. cit.*, p. 6.

We know now that marine fossiliferous limestones and sandstones occur (with *Eurydesma cordatum, Spirifer,* &c.) interbedded with the Lower Bowen Volcanics in extra-Bowen areas, e.g., Tooloombah (?), Collaroy, and Wilangi. With this in mind, as well as the lithological character of the Lower Bowen rocks in the type district, take the very interesting description of the "Gympie" beds in the Dawson River and their relation to the other Permo-Carboniferous beds as given in the following extracts*:—

> The rocks are classed as Gympie Formation and throughout the whole length of the area examined—from Banana in the south to the Isaacs-Mackenzie junction in the north—no indication could be seen of a stratigraphical break between this formation and the beds comprising the Lower Bowen Formation (=*Middle and Upper Bowen of Bowen River Coalfield.—J.H.R.*). There is undoubtedly an apparent if not real conformity between the two formations. . . .
>
> The igneous rocks associated with the Gympie beds are basic, intermediate and acidic in composition. They occur in many forms and connected with them are tuffaceous deposits interbedded with marine limestones.
>
> . . . There is no doubt of the existence of marine beds below the volcanic belt of the Lower Marine Formation at Chino Bluff, on Boomer Range, and also no doubt that this volcanic belt dies out in the southerly extension of the Lower Marine Series.

These descriptions of the "Gympie" beds as to lithological character could apply to any of the Lower Bowen areas just mentioned, and there is further the apparent stratigraphical conformity with the Marine Series over a distance of 110 miles along the strike of the beds. There can also be no doubt that the Lower Bowen Formation at Tooloombah is continuous with the beds mapped as "Gympie" Formation at Tooloombah Gap, only 12 miles further to the south. At the same time it is certain that rocks at least of Lower Palæozoic age occur with these Gympie or Lower Bowen Areas, as, for example, the talcose slates and phyllites of Rannes and other localities.

It is suggested that the Middle Bowen (Collinsville) Coal Measures are either missing in this field or are so unimportant in thickness as to have escaped detection by reconnaisance mapping, as well as in the Mount Britton and Yatton areas. To proceed to a comparison of the higher beds Mr. Dunstan mentions in the description of the Lower Coal Measures (or Anthracitic Series) around Kianga the occurrence of the fossil tree trunks in silica and ironstone.† If reference is made to the description of the Upper Bowen Formation in this report it will be noticed that these occurrences seem identical with those at Blenheim, Havilah, &c.; also that these fossil tree horizons are most characteristic of the Upper Bowen. Mention is also made of the occurrence of cone-in-cone limestone, another feature common in the Upper Bowen at Stoney Creek, &c. This evidence is in keeping with the correlation based on Cameron's and the writer's mapping.

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* B. Dunstan. *Op. cit.*, p. 6.

† B. Dunstan. *Op. cit.*, pp. 12 and 13.

In the Oakey Creek-St. Mary's section,* showing Upper Marine and Upper Freshwater beds, the presence of silicified tree trunks is mentioned in the latter also which is again suggestive of the Upper Bowen. The Upper Marine Series (St. Mary's) of the Dawson River has apparently no equivalent on the Bowen River unless it be the marine horizon (Upper Bowen) at Havilah, which locality is hundreds of miles to the north, and speculation as to the possibility of uniting them is useless. The absence of any important marine series on the Bowen field, above the horizon of the Dawson "Lower Marine," combined with certain lithological characters common to both the Upper and Lower Freshwater Series, as described by Mr. Dunstan (e.g., bright-yellow sandstones, silicified trees), suggests the question of the possibility of the "Upper Marine" beds at St. Mary's being portion of the "Lower Marine" series brought again to the surface by folding, and that consequently the Upper and Lower Freshwater Series both possibly belong to the very thick Upper Bowen Formation of the type district. An examination of the sections and the mapping would also appear to favour, rather than disfavour, this suggestion, as the area is a succession of folds with the axis of folding bearing N.N.W. to S.S.E. For instance, on Lorraine Creek, about 25 miles S.E. of St. Mary's, there appear to be more easterly than westerly dips, which might suffice, if the detailed structure could be worked out, to bring the "Lower Marine" beds up to, or near, the surface in the vicinity of St. Mary's since they are lying comformably underneath.

As to the probable unconformity between the Upper and the Lower Bowen Series of the Dawson it can be said that there is no evidence of such on the Bowen River field in the Permo-Carboniferous beds.

As a basis for the correlation of the Bowen River and Dawson-Mackenzie fields the combined mapping of Cameron† and the writer can be taken as showing that the Lower Marine, in greater part, and Lower Freshwater Series of the Dawson are equivalents of the Marine Series of Middle Bowen age and of the whole or portion of the Upper Bowen Formation respectively. The "Gympie" Formation (in part) of the Dawson, in the opinion of the writer, is the equivalent of the Lower Bowen. As to the upper divisions of the Dawson above the Lower Freshwater Series it is suggested that the non-marine beds are portions of the very thick Upper Bowen Series (9,800 ft.) while the marine beds of St. Mary's might possibly be the upper portion of the Middle Bowen Marine Series.

As the suggested unconformity within the Permo-Carboniferous beds in the Dawson field basin appears to be based on the horizontality of the upper strata while the lower formations, from top to bottom, are undulating or contorted† it may be relevant to mention that in the Bowen River field the Permo Carboniferous beds are often vertical on the east, while on the

* B. Dunstan. *Op. cit.*, pp. 16 and 17.

† B. Dunstan. *Op. cit.*, p. 22.

west near the Leichhardt Range they are so gently undulating that there is only an angular unconformity between them and horizontal Tertiary beds ranging up to about 7°. This condition probably applies to the Dawson field where the upper and horizontal beds are not shown on the map of that field to occur on the eastern side of the field where the lower beds are considerably contorted.

The suggested correlation in table form is as follows:—

BOWEN RIVER FIELD.		DAWSON-MACKENZIE FIELD.
REDCLIFFE PLATEAU SANDSTONES (Trias ?)		= Black Downs Tableland
UPPER BOWEN (9,600 ft.)	Sandstones, tuffs, &c., with undifferentiated coal measures	= (?) Upper Bowen Formation; (?) Upper Freshwater Series; Lower Freshwater Series
MIDDLE BOWEN (3,100 ft.)	Marine Series (2,400 ft.)	= Lower Marine Series (in part)
	Collinsville coal measures (700 ft.)	= Missing or undetected
LOWER BOWEN (5,400 ft.?)	Mount Devlin volcanics (2,000 ft.); Mount Devlin coal measures (400 ft.); Mount Toussaint volcanics (3,000 ft. ?)	= Gympie Formation (in part)

Clermont-Capella Area.

These Permo-Carboniferous marine beds and coal measures were first provisionally classed as Middle Bowen Marine Series and Upper Bowen respectively, and subsequently in the light of later work in the Dawson-Mackenzie field were both relegated to the Upper Bowen. The Bowen and Clermont beds, in view of the great distance separating them, in which no evidence is yet available, can scarcely be correlated at present on a secure basis, particularly as the nature of the marine beds at Clermont is so little known. The available evidence supports the opinion that the first correlation suggested is probably correct, i.e., that the Clermont marine beds belong to the Bowen Marine Series (Middle Bowen) and consequently the coal measures to the Upper Bowen. The following grounds for this belief are perhaps slight but are supported by observations of Jack and Rands.

The Logan Downs marine section to the north of Clermont is equivalent to that at Collinsville.

(1) There would appear to be only two Permo-Carboniferous Marine Series in Central Queensland—viz., the Middle Bowen (= Upper Marine of N.S.W.) and the Lower Bowen Marine-volcanic (= Lower Marine of N.S.W.). The absence of volcanics above the Clermont marine fossil beds is suggestive that they are

Middle Bowen Series, as is also the presence of fossils in ironstone. At Bowen River the fossils are mostly casts in ironstone bands in ferruginous sandstones.

(2) The Middle Bowen beds, where seen furthest south by the writer on the western side of the Bowen River field near the Leichhardt Range, are trending south by west—i.e., in the direction of Clermont. This is about 120 miles from Clermont but Rands* records *Cyathophyllum*, *Strophalosia Clarkei*, and *Productus* from Logan Downs, 40 miles N.N.E. of Clermont, which is nearly midway between the two areas of marine beds under consideration. Immense tracts of later basalt cover the Permo-Carboniferous beds north-east of Clermont, but it is very probable that future work will succeed in connecting the Bowen River Marine Series with those on Logan Downs.

(3) All the genera recorded at Clermont from the marine beds are present on the Bowen River except possibly one (*Conularia*).

(4) Jack† records *Productus* and *Protoretepora* at Capella in a matrix of ferruginous sandstone very much resembling the sandstones of the Middle Bowen, which appears strong evidence considering his knowledge of the Bowen field. Dunstan‡ states that it seems quite probable the marine beds of Capella are the same as those at Clermont.

Mackay and The Styx Coastal Areas.

The volcanic rocks of the Lower Bowen Formation are well developed in the coastal districts of Mackay and The Styx. The presence of a basal Volcanic Series has been noted by Maitland,§ Cameron,‖ Ball,¶ and Reid.** They have been mapped by Maitland in the Mackay and Nebo districts, and he shows their almost uninterrupted continuity, through the Coastal Ranges, with the extension of the Bowen River beds towards Nebo. This formation also occurs at Tooloombah in the Styx district, and there the sandstones contain typical Permo-Carboniferous marine fossils. Rands, who mapped and described a large Permo-Carboniferous area in the Styx and the St. Lawrence districts†† collected marine fossils from Wilangi at a spot about 15 miles south of St. Lawrence which included *Eurydesma cordatum*, since identified as such by Dun. The *Eurydesma* beds

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* W. H. Rands. Q.G.S. Pub. No 27, p. 3. Geology, &c., in vicinity of Clermont.

† R. L. Jack. Q.G.S. Pub. No. 103, p. 10.

‡ B. Dunstan. Q.G.S. Pub. No. 148, p. 3.

§ A. Gibb Maitland. Q.G.S. Pub. 58, pp. 11-12.

‖ W. E. Cameron. Q.G.S. Pub. 181, p. 7.

¶ L. C. Ball. Q.G.S. Pub. 229, p. 43.

** J. H. Reid. Permo-Carb. Geol. of Queensland. Additional Notes. "Queensland Government Mining Journal," February 1924, p. 46.

†† W. H. Rands. Q.G.S. Pub. 84, pp. 8 and 9.

lie within the extension of the volcanic-marine beds of Tooloombah. Thus far the interbedded sediments of this formation have been found to be of marine origin on the coastal area and of freshwater origin on the Bowen River Coalfield.

Overlying the Lower Bowen, apparently conformably in all instances, are the extensive coal measures of Black Rock and St. Helens Creeks, Hampden, &c., and Oakey Creek, possibly all to be correlated with the Collinsville Coal Measures. The Middle Bowen Marine Series has not yet been found over these, but this formation is in all probability present in the Mount Brunswick area of the Styx district, where marine beds, some of which resemble most strongly certain Bowen River marine sediments, although without the glacial erratics as far as known, lie about 6,000 ft. above the horizon of the marine beds of the Lower Bowen at Tooloombah Homstead.*

Apparently no strata belonging definitely to the Upper Bowen Formation have yet been identified in this coastal area.

Bowen River.		Coastal Areas (Mackay-Styx.)
Upper Bowen	Freshwater series with coals, fossil trees, &c.	(?) (?) (?)
Middle Bowen	Marine Series	= (?) Mount Brunswick, &c., marine beds
	Coal Measures	= (?) Coal Measures of Oakey Creek
Lower Bowen	Volcanics, &c. / Coal Measures / Volcanics, &c.	= Volcanics and marine beds of Oakey Creek (?), Wilangi, Tooloombah, &c.

* J. H. Reid. Permo-Carb. Geol. of Queensland. Additional Notes, "Queensland Government Mining Journal," February 1924, p. 46.

A. J. Cumming, Government Printer, Brisbane.

Geological Sketch Map of the BOWEN RIVER COALFIELD

By
J.H.Reid. A.S.T.C.
Govt. Geologist
1924

Scale of Miles
4 3 2 1 0 4 8 12
T.H.B

N. M.N. 6°30

The Twins
Table Mt
Quartz Porphyry
Volcanics with occasional sandstones
CLARKE RANGE
Mt Toussaint
Strathmore Hd Sn
Volcanics
Mt Devlin
Coal Measures Volcanics
Sonoma Peak
COLLINSVILLE
Consolidated Mine
Pelican
Coral
Mt Vista
Sonoma Hd Sn
Belmore
SECTION LINE
Birralee Hd Sn
Two Mile Gully
Tuffaceous Sds
BOWEN
Emu Plains Hd Sn
Ten Mile Hill
BROKEN RIVER
Havilah Hd Sn
Mt St Martin
Calc Sd with Fossilwood
Bald Hill
Rosella Ck
Mt Leslie
Mt Razorback
Glossopteris shales
Calc Sd
Tuff Sds
Byerwen Hd Sn
Redcliffe Tableland
Redcliffe Vale Hd Sn
Blenheim Hd Sn
Mt Tooth
Mt Blenheim
EUNGELLA
Eungella Hd Sn
Stockton
Volc Sill
Sandy Soil
Basaltic Soil
Newlands
LEICHHARDT RANGE
Limestone Hill
Interbedded Basalt
Mt Hillalong
Fer Fuginous Sds
Sutton Ck Hd Sn
Sutton Ck
4' Coal reported in well
Mt Hillalong Hd Sn
Tuffaceous Sds & fossilwood
DENHAM RANGE
Red Cliffs

REFERENCE

- TERTIARY — Basalt Pinnacles
- TRIASSIC (?)
- PERMO-CARBONIFEROUS
  - UPPER BOWEN — Fresh water series with marine horizon
  - MIDDLE BOWEN — Marine series
  - MIDDLE BOWEN — Collinsville coal measures
  - LOWER BOWEN — Volcanics, Sandstones Mt Devlin coal measures
- LOWER PALEOZOIC
  - Granite &c
  - Metamorphics

Geological Boundaries Mapped
Assumed
Principal Roads
Railway Line
Section Line
Dips Horizontal Vertical Strata

Geological Map of COLLINSVILLE DISTRICT

(BOWEN RIVER COALFIELD)

By
J. H. Reid
Govt Geologist

Scale of Chains
40 0 40 80 120

Mt Toussaint
Por 11
Por 12
Por 13
Por 14
Coal & Sd reported hereabouts by A.J. Hall Scott probably continuation of Mt Devlin Coal Meas
Sandstones interbedded with Volcanics
Stock Res
Probable boundary Mt Devlin Coal Measures
Mt Devlin
Pelican Creek
Decomposed Granite
Hospital
COLLINSVILLE
State Colliery
Consolidated Mine
SCOTTVILLE
State Reserve No 2
State Reserve No 1
Sonoma
Port Denison Coal Co Bore completed at 1005 ft No coal. Marine strata to 960 ft possibly to bottom of bore. Carrick seam probably occurs between 1100 ft and 1150 ft
Approx position only of this spot
Slight
Shaft
Coal 3'10"
Blake (?) Seam
Bowen (?) Seam
Bowen Seam
Denison Seam
Scott Seam
Carrick Seam
Key Bed for Coal Seams Underneath
Three Mile
Astartila Bed 30' above Carrick Seam
Large Granite Erratic
Porphyrite Dyke
Porphyrite Sill
Derbyia Horizon
Strophalosia Horizon
Approx position here
Approx position of Coal Seam
Coal Seam
Railway
Roads
Strikes & Dips
Horizontal Strata
Diamond Drill Bores
Section Lines

REFERENCE

PERMO-CARBONIFEROUS
- MIDDLE BOWEN
  - Marine Series
  - Middle or Collinsville Coal Measures
- LOWER BOWEN
  - Mt Devlin Volcanics
  - Lower or Mt Devlin Coal Measures
  - Mt Toussaint Volcanics &c.

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Queensland.

DEPARTMENT OF MINES.

Queensland Geological Survey.

(B. DUNSTAN, CHIEF GOVERNMENT GEOLOGIST.)

PUBLICATION No. 277.

Geological Reconnaissance

BETWEEN

Roma, Springsure, Tambo and Taroom

(The Carnarvon Ranges and Buckland Tablelands).

By

H. I. JENSEN, D.Sc.

Assisted by J. R. T. DUNLOP.

(With 13 Maps and Sections.)

BRISBANE:

BY AUTHORITY: ANTHONY JAMES CUMMING, GOVERNMENT PRINTER.

1926.

PREFATORY NOTE.

THE voluminous notes contained in this report by Dr. Jensen on the Geological Reconnaissance of the area bounded by Springsure on the north, Roma on the south, Taroom on the east, and Tambo on the west, will prove very interesting reading to the geologist and prospector in being full of details concerning the numerous places visited and examined. The work around Roma has revealed many peculiarities of structure and has altered our conception of the geological sequence of the strata in this district, while in the country to the north of the Great Dividing Range Dr. Jensen has, for the first time, given a very welcome description of its geological features.

In a work of such magnitude, the traverse has necessarily been very rapid, and the survey was completed in a very short space of time, and consequently it would be too hazardous to take *in globo* all the deductions he draws, or to consider his geological mapping more than an expression of what he considers would ultimately be found to be correct on a thorough examination—it must be considered, as expressed in the title, a geological reconnaissance. Nevertheless, the work is a very useful addition to our literature on Queensland geology and will be issued as Publication 277.

B. DUNSTAN,

Chief Government Geologist.

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GEOLOGICAL SKETCH MAP of ROMA SPRINGSURE AREA

Illustrating Report by

H.I. JENSEN D.Sc
Assisted by J.R.T. DUNLOP

Reference

- UC Upper Crêtaceous
- LC Lower Cretaceous
- UW Upper Walloon
- MW Middle "
- LW Lower "
- Jurassic
- Bd Bundanba
- Ip Ipswich
- Cl Clematis
- Triassic
- UBl Upper Bowen
- MB Middle "
- LB Lower "
- Permo-Carb
- S Star = Carboniferous
- Q Metamorphics (Age Unknown)
- Ba Basalt
- UTrl Trachytes & Rhyolites

Scale of Miles
0 8 16 32
M.N.R.

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Geological Reconnaissance

BETWEEN

Roma and Springsure, Tambo and Taroom

(The Carnarvon Ranges and Buckland Tablelands)

BY

H. I. JENSEN, D.Sc.

Assisted by J. R. T. DUNLOP

PART A.

I.—INTRODUCTORY.

THE area falls naturally into two sections—a southern area lying between the Western Railway and the Carnarvon Range, and a northern area lying to the north of the Carnarvon Range, dealt with in Part C. During 1920 the southern area was examined.

Physiographically and geologically this southern area is remarkable for paucity of rock outcrops, hence the geology of considerable stretches had to be sketched in from their resemblance in soils and vegetation to other better defined parts. Since this method of geological interpretation is liable to error from mistakes of judgment on the part of the observer, it is quite likely that future bore data may lead to alteration of our maps.

The special subjects of research in the investigation of the southern area here dealt with comprise the following:—

(1) The demarcation of the geological formations met with in the area.

(2) The determination of dips with a view of locating folds, synclines and anticlines, &c., which may be of use in fixing sites on which to bore for oil, and the collection of other evidence of the presence or absence of oil in the formations.

(3) The correlation of the section obtained in the Roma oil-bores with surface geology.

(4) The determination of the thickness of the Walloon, Bundamba, and Ipswich series and of the subdivisions of these series.

(5) Faults, if any, and their likely effect on oil.

(6) The nature and origin of artesian water, and the possibility of getting artesian water in certain areas now considered outside the artesian system.

(7) The examination of the coal measures in the various formations of the district.

(8) The cause of the strong westerly projecting sinuosity in the isopotentials south of Mount Hutton.

(9) The source and mode of origin of the boulder mounds and boulder hills which occur widely throughout the area, and their bearing on Mesozoic and Tertiary geological history.

(10) The age and nature of the volcanic rocks of the district and their relation to faulting.

(11) The scenery of the district and its relation to earth movements.

(12) Collection and determination of fossils.

(13) The correction of the geological map of that part of the State.

(14) The soils of the district and their relation to geological formations.

In the examination of the district south of the Dividing Range the writer was assisted by J. Dunlop, Geological Field Assistant.

After the examination of the southern area it was decided by Mr. Dunstan, the Chief Government Geologist, that the investigation of the Carnarvon Range area should be continued northward as far as the Central Railway system, so as to connect up with other areas already examined by geologists. The country examined contains large areas which are among the roughest in Queensland and also very remote from settlement and railway connection. The only means of carrying camping equipment through this district was by the use of packhorses. Travelling light with the minimum of gear, the great amount of wet weather experienced caused considerable personal hardship to the members of the party, consisting of the writer and two wages men, but no serious delays or accidents.

The area investigated was one practically unknown to geologists. Previous investigations have only touched upon the outskirts of the area, and the geological features suggested by the existing geological may of Queensland are largely deductions made from hearsay information which was not too reliable.

Early in 1922 the investigation was continued and the country around Tambo, Caldervale, and Augathella was examined. (*See* Part E.) Much additional information was obtained in this quadrant, especially on the question of the relationship of the Desert Sandstone to the Marine Cretaceous. I am indebted to Mr. Millar, of McFarlane Downs Station, for great assistance in getting over the country in these parts.

In August 1922 the country north and north-west of Taroom was investigated by a traverse from Taroom to Coorada,

viâ Gwambagwine, thence to Ghinghinda, and *viâ* Palm-tree to Taroom. (*See* Part D.) With the assistance of Mr. Dunlop, Assistant Geologist, I continued the investigation north along the valley of the Dawson, through Spring Station, Nathan's Gorge, Cracow, and Delusion-Creek to Camboon Woolshed, thence to Camboon, thence back to Taroom through Rocky Bar Station and Cockatoo Station.

Mr. Dunlop then continued the work by crossing the range again *viâ* Bungaban to Auburn Station, whence he proceeded to Chinchilla.

The geological reconnaissance outlined in this bulletin embraces about 50,000 square miles of country.

II.—LITERATURE ON THE REGION.

The geological map of Queensland published by Dr. Jack in 1899 forms the basis of all subsequent work. On this map Dr. Jack shows most of the country between the Carnarvon Range and the Cretaceous border coloured Ipswich which in those days was synonymous with Mesozoic, and included Bundamba and Walloon (Upper Trias and Jurassic), as well as the Ipswich proper (Middle Triassic). Subsequent geological maps, the principal of which is the map accompanying Mineral Index by B. Dunstan, make no attempt to separate the different groups of Mesozoic formations, but the age of the ensemble is given as Walloon (Jurassic), apparently because the fossils collected north of the Cretaceous border were Jurassic. In all these maps an enormous number of sandstones occurring in the Dividing Range are coloured Desert Sandstone. These have in the course of the present investigation been proven to belong to various Mesozoic series older than Cretaceous.

The geology of the country north of Roma is, with the exception of the early work of Dr. Jack and Mr. Gibb Maitland, which is comprised in the Geological Map of 1899, closely bound up with the Roma Oil Bore. The easiest way, therefore, to deal with this part of the literature is to give a résumé of the history of the Roma Oil Bore.

A.—Summary of Recommendations and Reports dealing with Oil at Roma.

Early Reports Prior to 1915.

Mr. Cameron.—Q.G.S. Publication No. 247, "Petroleum and Natural Gas Prospects at Roma," by W. E. Cameron, B.A. (Cantab.), gives an excellent historical summary of all the events which led up to oil prospecting at Roma, and also of all geological reports and work done on the subject up to 1915, the year of issue of the said geological publication. The following is a condensed summary of the salient points of the contents:—

Natural gas was struck at Roma in the course of water-boring in the year 1900, and again in 1908 in the bore put down by the Roma Mineral Oil Company, in both cases at a depth of about 3,700 ft.

J. E. Carne.—Mr. J. E. Carne, Assistant Government Geologist of New South Wales, also, in "Bulletin No. 1 of the Territory of Papua" (1913), expressed the view that the gas at Roma came from coal-seams and was not indicative of petroleum.

The Queensland Government had already, on Mr. Cameron's recommendation (dated 1-7-12), submitted all reports and data bearing on the question to distinguished petroleum experts in other parts of the world, including Dr. A. C. Veatch, Mr. P. C. A. Stewart, Mr. W. H. Dalton, F.C.S., F.R.S., and Sir Boverton Redwood, for their advice and opinions.

Dr. Veatch.—Dr. Veatch (26-11-12) advised further drilling operations by experienced artesian well-borers, and the cementing off of each water-flow as it was struck before continuing boring.

Sir T. Robinson and Sir Boverton Redwood.—Sir T. Robinson, Agent-General for Queensland, wrote on 7th January, 1913, giving a digest of the opinions of various oil experts whom he had communicated with, and advised the employment of an experienced oil-driller. The opinions expressed by Sir Boverton Redwood are specially emphasized. Sir Boverton recommended starting with 15-in. casing and the use of a Parker's rotary drill.

Dr. Veatch again.—Mr. Carne's adverse view on the possibility of oil occurring at Roma was subsequently submitted to Dr. Veatch and the other experts for an opinion, and in November 1913 Dr. Veatch wrote expressing agreement with Mr. Cameron's views and disagreement with those of Mr. Carne. He, however, recommended "a careful instrumental survey" of the minor structural features prior to locating a site for a test-bore.

Mr. Stewart.—Mr. Stewart also wrote a report concurring with that of Dr. Veatch, and emphasized the need of a preliminary geological survey.

Mr. Cameron.—On 6th March, 1914, and again on 24th March, 1914, Mr. Cameron wrote a report in which he draws special attention to the impossibility of making a geological survey of blacksoil plain country like Roma, and he recommended instead the drilling of shallow diamond-drill holes to determine structure, before plunging into the expenses of sinking an oil-bore to a depth of 4,000 ft.

Mr. Dalton.—Mr. W. H. Dalton, F.G.S., F.C.S., in a letter to Sir Boverton Redwood, dated 29th April, 1914, gave his opinions on the matter. He expresses the view that the Roma

gas is undoubtedly oil-gas. He further suggests that the rocks from which the gas comes may be Permo-Carboniferous, and that there is likely to be an unconformity between them and the overlying Cretaceous. Accordingly he condemns Mr. Cameron's idea of drilling shallow bores to determine structure. However, he recommends further bores.

Sir Boverton Redwood.—In a letter dated 30th April, 1914, Sir Boverton Redwood expresses concurrence with Mr. Dalton's views. In a letter of the 13th May, 1914, the same authority advises core-drilling to enable a thorough geological examination to be made of the strata.

Mr. L. C. Ball.—Finally, on 29th June, 1914, the reports were submitted to Mr. L. C. Ball for comment. Mr. Ball concluded that "a strong case can be made out for the sinking of one deep bore near those at Roma, rather than several shallow ones." However, Mr. Ball has in mind a diamond-drill hole as recommended by Sir Boverton Redwood.

Result.

Apparently in consequence of these reports, the sinking of one deep bore as recommended by several of the above authorities was decided on, but not the diamond-drill hole advised by Sir Boverton and Mr. Ball; it was started with casing of the dimensions recommended by Sir Boverton Redwood, and an experienced oil-driller was appointed to take charge as recommended by Sir T. Robinson, instead of an experienced artesian driller as recommended by Dr. Veatch.

The Age of the Rocks below Roma not Understood.

Through the whole of these deliberations, decision is made difficult by a lamentable lack of knowledge of the nature, age, and structure of the rocks from which the gas came.

There was one investigation, that of Messrs. Saint-Smith and Thom, into the delimitation of the artesian basin between Wallumbilla and Blythesdale, which seems to have received insufficient attention. The said survey party made a traverse from Blythesdale to Hornetbank, and found Walloon rocks lying conformably on one another the whole distance with a gentle southerly dip, giving a sufficient thickness of sediments of Walloon age to shatter Mr. Dalton's objections to Mr. Cameron's recommendation (Artesian Conference, Brisbane, 1914). Mr. Dalton's fame as a chemist gives weight to his opinion that the Roma gas is derived from oil, but his suggestion that the containing rocks are Permo-Carboniferous was based on Mr. Carne's views, and was wholly unwarranted, since Mr. Carne had no experience of Western Queensland. Sir Boverton Redwood was apparently also under the same misapprehension. Hence Mr. Cameron's thoroughly sound recommendation of preliminary drilling to determine structure was swept aside.

Dr. Veatch's and Mr. Stewart's recommendations to have a careful geological survey made prior to boring would have led, if followed, to the complete shattering of the Permo-Carboniferous theory and of Mr. Dalton's objections to shallow preliminary boring. But, for reason ably put by Mr. Cameron, the shallow drilling would still be necessary to determine "minor structures," which cannot be determined by surface geological survey within ten miles of Roma.

Mr. Cameron's recommendations were sound, and it is regrettable that so little was known of the country north of Roma, since such knowledge would have enabled Mr. Cameron to reply effectively to Dr. Dalton's theory.

From 1915 to October 1920 there are no official reports or publications of a geological nature dealing with the Roma oil-bore, since drilling was in progress on the adopted plan. When the accident to the tools occurred (24th May, 1919), Mr. Cameron made a brief report (29th July, 1919). On 14th September, 1920, and 13th November, 1920, Mr. Cameron reported on a "Recent Flow of Gas at Roma."

The Advisory Committee.

In November 1920 the Hon. the Minister decided to appoint a committee of advice to make recommendations to him on all questions connected with the Roma Bore. Messrs. A. Moore (driller in charge, Roma), Mr. J. B. Henderson (Government Analyst), and Mr. W. E. Cameron (Deputy Chief Geologist—chairman) were appointed to the committee.

This committee furnished to the Hon. the Minister a number of reports and recommendations dealing principally with (1) the methods of utilising the Roma gas supplies, (2) the possibility of making petrol commercially from the gas.

The committee investigated the cost of erecting a plant to make petrol from the gas, the possibility of utilising the gas commercially in running woollen mills, in the manufacture of carbon black and printer's ink, in cement-making and glass-blowing.

The committee decided that expenditure on such industrial undertakings was unwarranted until further drilling gave satisfactory evidence of the existence of gas supplies extensive enough to last for many years.

Further Geological Work.

Now, in regard to further geological reports and recommendations on the oil question, the Chief Geologist, Mr. B. Dunstan, in May 1920 instructed Dr. Jensen to undertake a geological examination of the Roma district.

After preliminary investigations Dr. Jensen found, as

Mr. Cameron had found before, that it was impossible to arrive at geological facts in the plain country around Roma. He consequently set out to investigate the range country forty to fifty miles north of Roma first. After obtaining reliable geological data there he worked back towards Roma, and succeeded in getting dips around Orallo, and along the Injune railway to within ten miles or so of Roma.

From Dr. Jensen's investigations it is now clear that the whole of the series bored through at Roma consists of Walloon rocks, that there is no unconformity, and that the rocks at the bottom of the Roma bore are the equivalents of the Injune Creek horizon of interlaminated shales, calcareous shales, carbonaceous beds, and coal-seams. The rocks of the 3,700-ft. depth in the Roma bore now appear to be the equivalents of the rocks outcropping about 53-55 mile on the Injune line, since the lower Walloon coals of Injune Creek have not yet been pierced in the Roma bore. The occurrence of workable coal in an oil series is not unusual, since the Cherokee series, which are the richest oil reservoirs in the Midcontinental Field of America, contains similar rocks to our Lower Walloon and are also coal-bearing.

Dr. Jensen's Recommendations.

Dr. Jensen recommended—

(1) That trial bores be put down in the Orallo district, because in that district the possible oil-bearing strata would be met with less than 2,000 ft. from the surface, and because the district is dissected enough to permit a geologist to determine structures roughly.

(2) That shallow diamond-drill holes be put down to enable minor structures (anticlines, monoclines, &c.) to be determined more accurately.

Dr. Jensen's report (Q.G.M.J., March 1921) also shows that the Injune area is one of high salinity where cattle do not require salt, while salt is required by stock both in the country to the south at Cornwall and Orallo, and in the country to the north at Westgrove-Crystal Brook.

This is of importance in regard to Mr. Cameron's statement in Q.G.S. Publication 247, aforementioned, page 18, that "the only respect in which the Roma occurrence is unique is in the absence of brine accompanying the gas."

It is also shown that seepages would be highly improbable in blacksoil country and would pass unnoticed for many years, if present, owing to the brigalow scrubs.

Dr. Jensen further examined the country in and north of the Carnarvon Range, and arrives at the conclusion that the Upper Bowen formations are geologically as favourable for oil as the Lower Walloon (Q.G.M.J., October 1921).

Summary of Recommendations.

The actual recommendations made on the further boring for oil are therefore—

(*a*) Those of the committee or advisory board in which it is recommended—

(1) To sink further bores near Roma to determine the extent of the gas pocket, with a view to starting industries and possibly striking oil.

(2) To purchase at least one drilling plant (preferably two) to expedite such boring, the committee having adopted Dr. Veatch's view as regards the type of plant required.

(*b*) Mr. Moore's recommendation to purchase the plant specified in his letter of 2nd October, 1921, and answering to the description of the plant recommended by the board.

(*c*) Dr. Jensen's recommendation to bore with a view of testing shallower ground, such as in the Orallo district, where he estimates that the possible oil-zone will be struck at less than 2,000 ft. Also a recommendation to bore preliminary shallow diamond-drill holes to determine structure more accurately than can be done by inspection in areas where outcrops are few.

The recommendations of the Advisory Committee are put clearly with a view to making a survey of the Roma gas pocket, as a preliminary to starting industrial undertakings.

The recommendation of Dr. Jensen is with a view of tapping possible oil supplies at shallower depths, where such oils are not as likely to have undergone transmutation to solid and gaseous hydrocarbons through heat and pressure.

The geological survey recommended by Dr. Veatch may be said now to have progressed sufficiently far to make the nature of the beds underlying Roma clear. Dr. Veatch's warning that all water must be carefully shut out in deep drilling to obtain any oil indications at all is one that applies to artesian bores as well as oil-prospecting bores. A possible oilfield may easily be ruined by a deep artesian bore.

Dr. Veatch's recommendation that trial boring should be done, as in Texas, with an artesian plant under a competent artesian driller who understands cementing off the water flows as they are met with, is also a suggestion of great value, since it makes for economy in future drilling.

B.—The Literature of the Whole Region.

The country north of the Dividing Range and south of the Central Railway is not so flat and poor in outcrops. It has therefore received more attention in geological literature. No comprehensive work has been done on it, but individual portions are dealt with in numerous bulletins.

Considerable confusion of ideas must exist in the mind of any student of geology reading the bulletins of the Geological Survey which deal with this area, owing to the use, in a vague and varying manner, by different investigators such terms as "Blythesdale Braystone," "Desert Sandstone," "Upper Bowen," "Lower Bowen," "Middle Bowen," "Upper Marine," "Lower Marine," "Upper Freshwater," "Lower Freshwater," and a multitude of other terms which may be satisfactory enough if used in a limited sense, as descriptive of formations met with in a specified area, but which are not capable of general application unless much more strictly defined.

The present work has been carried out in an area in which all formations from the Star Beds (Lower Carboniferous) to the Cretaceo-Tertiary lie the one upon the other in regular sequence at gently dipping angles. Fossils have been obtained in many places and in numerous horizons, thus giving a means of arriving at the type fossils of each age; and an endeavour will be made to define the character of the sediments of each geological period as arrived at by this investigation, and thus clear up some of the misconceptions and confusion of thought at present extant.

The literature which bears on the geology of the area under review is not extensive and may be summarised as follows:—

Bulletin 27.—Report on the Geology and Mineral Deposits of the country in the vicinity of Clermont, by W. H. Rands, Assistant Government Geologist, 1886. This paper emphasizes the fact that many of the Clermont drifts overlie Glossopteris-bearing shales. Devonian and still older Palæozoic rocks are also found in the area.

Bulletin 81.—Sapphire, Gold, and Silver Mines near Withersfield, by R. L. Jack, Government Geologist, 1892. The strata for the first three miles north-north-east from Withersfield are correlated with those of Bogantungan and Hannam's Gap and are assigned to the Star Beds (Carboniferous). Granite gneiss and mica schists are then met with to the sapphire mines at Anakie.

Bulletin 102.—The Eidsvold Goldfield, by R. L. Jack, 1895. This bulletin deals purely with the mines at Eidsvold and has no stratigraphical value.

Bulletin 103.—Annual Progress Report of the Geological Survey for 1894. This report contains various notes of interest

in connection with the district under review. Mr. A. C. Gregory's report of the discovery of coal near the head of Bungeworgorai Creek is mentioned, as a result of which, together with the discovery of fossil ferns near Juandah, Dr. Jack considered the head of the Dawson to be Ipswich formation instead of Bowen as formerly. The Miles sandstones are regarded as Desert Sandstone, as are the sandstones between Yeulba and Kangaroo Creeks; a bed of coal is mentioned as occurring in Chinaman's Creek, an affluent of Yeulba Creek. The report deals largely with the "Blythesdale Braystones," their nature, extent, and significance. In the light of recent investigations, this formation has been discarded or at least reduced to a very thin horizon at the top of the Upper Walloon, which does not correspond with the zone from which our main artesian water supplies are drawn.

Page 9 of this report gives an interesting account of the geology of Mantuan Downs, and makes mention of fossils obtained from Dilly, Wealwandangie, and other localities in the Springsure district, accordingly assigned to Gympie age. The trachytes of the Minerva district and Springsure basalts are described by Dr. Richards in the Journal of the Roy. Soc. of Q., vol. xxx., Nov. 1918.

Considerable confusion of ideas results from the wide application given by early geologists to the term "Desert Sandstone."

Bulletin 148.—The Permo-Carboniferous Coal Measures of Clermont and Associated Formations, by B. Dunstan, F.G.S., 1900. Fossiliferous limestones from Douglas Creek containing Favosites, Cyathophyllum, Stromatopora, Syringopora, Pachypora, Pentamerus, Atrypa, and Gasteropod fragments are assigned to the Devonian. The older schists and slates are Silurian or older. Marine Beds were found on the northern side of Drummond Range or to the south of Clermont at Capella. The fossils collected from Quarry Hill shaft include Edmondia, Fenestella, *Dielasma saccula* (Martin), Mourlonia sp., *Conularia inornata* (Dana), *Martiniopsis subradiata* (Sow.), *Productus brachytherus* (Sow.), Spirifera sp., Stenopora sp., Astartella sp., and *Aviculopecten multiradiatus* (Eth.). Mr. Rands regards the Marine as Middle Bowen and the Upper Bowen as a freshwater series. Glossopteris is the chief form in the Upper Bowen. The problem of the origin of "billy" is discussed and no satisfactory solution arrived at.

Bulletin 171.—The Opal Mining Industry, by C. F. V. Jackson, 1902, makes reference to the occurrences of opal at Springsure and Rainworth.

Bulletin 172, on the Sapphire Fields of Anakie, by B. Dunstan, 1902. In "Geological Outlines" Mr. Dunstan mentions that the Star Beds, which appear almost horizontal, remote

from the granites, dip at 60 to 70 deg. where in proximity to the Granites. This is undoubted evidence that some of the granitic intrusions of the Anakie belt succeeded the Carboniferous period. There does not appear to be any of the Bowen formations exposed *in situ* in the Anakie district, nor do the Mesozoic formations exist there. Mr. Dunstan's notes on the "billy" of the Anakie drifts are also of importance in correlating the occurrences of that formation in various areas.

It is obvious from Mr. Dunstan's survey of the district that, although Permo-Carboniferous sediments might once have overlain the metamorphic rocks of the Anakie belt, there has been a land period of long duration, probably extending through the whole of the Mesozoic and Tertiary divisions of geological history. During all this time gradual elevation has been in progress in the belt.

Bulletin No. 18, Old Series (Q.G.S. Publication 128), Notes on Fossil Plants from Duaringa, Ipswich, Dawson River, and Stanwell, by John Shirley, is of interest in connection with the Palæontology of the district.

Bulletin 226.—Geology of the Dawson and Mackenzie Rivers, with special reference to the Occurrence of Anthracitic Coal, by B. Dunstan, F.G.S., 1901. In his notes in previous geological work Mr. Dunstan gives a fine summary of the previous investigations bearing on his district. As all these notes are also of importance in connection with the Carnarvon Range area, the reader of the present report is referred to Mr. Dunstan's report on the Dawson-Mackenzie for fuller notes on previous literature. The quotations from Dr. Jack's Report on the Bowen Coal Field, 1897, are of particular interest, inasmuch as Dr. Jack's division of the Bowen into three formations is followed by the present writer, and the type of formations as well as of fossils in each division is closely analogous both in the type district and the Carnarvon Range region.

On page 8 of this report Mr. Dunstan identifies his Lower Bowen Marine Series west of Greycliff Station with the Middle Bowen of Dr. Jack. It is further evident that Mr. Dunstan's "Gympie" is largely synonymous with Dr. Jack's "Lower Bowen," but it includes also a retinue of metamorphic rocks which appear to be altered Star Beds. The areas which can be definitely correlated with the Lower Bowen comprise Slaty Gully on the eastern side of the Mackenzie River and bars of rock in the Mackenzie, with glacial erratics, also further north tuffs, breccias, and limestones with Aviculopecten and rugose coral, also below Windah crossing of the Fitzroy River where indications of ice action were also noticed, and between Thirsty Creek and Windah where volcanic rocks are interbedded with the sedimentaries.

The area reported on by Mr. Dunstan is a very difficult

one to work out, inasmuch as it is situated along the belt where the intense folding of the coastal ranges just commences to die out, and the same rocks are found in one place highly metamorphosed, in another but slightly so.

Mr. Dunstan's Lower Freshwater rocks are equivalent to Dr. Jack's Middle Bowen and to the present writer's Middle Bowen in part, except the volcanics, which may belong to the Lower Bowen in part. In the Carnarvon Range the Middle Bowen series was taken to commence from a limestone horizon—that of Dilly near Springsure, which, however, is considered the top of the Lower Bowen (Upper Carboniferous)—and to have another limestone horizon in the middle of the series in which no fossils were found.

Probably the former with some of the overlying sandstones is the equivalent of Mr. Dunstan's Lower Marine. His Lower Coal Measures are the equivalent of the present writer's Middle Bowen Coal Seams represented by the Consuelo Creek Coal, while his Upper Marine is the equivalent of the fossiliferous limestone at the base of the Upper Bowen Series of this report, and the Upper Coal Measures in the Lower Bowen of Mr. Dunstan are both in nature and fossil contents the equivalent of the Carnarvon Coals, and the belt described as Upper Bowen in this report. Mr. Dunstan's Upper Bowen, being the Tolmies-Clermont Coal Measures, should be the present writer's passage beds between the Ipswich and Upper Bowen. In the Dawson-Mackenzie Valley they lie, so Mr. Dunstan thinks, unconformably on the coal measures below. In the Carnarvon Range a thick sandstone series is intercalated between the two coal horizons, and there is no evidence of unconformity.

Bulletin No. 200.—The Central Queensland Coal Measures, by W. E. Cameron. Section II. of this Bulletin, dealing with Geology, is interesting as it points out how Mr. Dunstan's and Dr. Jack's formations or divisions of the Bowen rocks are comparable in the district examined by him. The present writer finds Mr. Cameron's remarks apply very well to the relationship of the formations as found in the Carnarvon Range district.

Sequence, Glaciation, and Correlation of Carboniferous Rocks of the Hunter River District, New South Wales, by C. A. Sussmilch, T. W. E. David, Walkom, and Browne, Jour. Proc. Roy. Soc. of N.S.W., vol. liii., 1920. Reference will be made in this report to the results arrived at by the authors of this paper. The Lower Bowen of the Carnarvon area is lithologically equivalent to the Upper Carboniferous of N.S.W. The Middle Bowen of the Carnarvons is the equivalent of the Ravensfield Sandstone and the Greta Coal Measures, while the Upper Bowen of the Queensland area becomes the equivalent of the N.S.W. Upper Coal Measures, and like these commences with a marine crinoidal horizon. The equivalent of the Branxton

glacial horizon was not met with. Thus the Middle and Upper Bowen of the Carnarvons become the equivalent of the Permian strata in N.S.W. (*See* Plate XXIX. ib.)

The Geology and Petrology of the Great Serpentine Belt of New South Wales, by Professor Benson and others, Proc. Linn. Soc. of N.S.W., also contains many points of interest in connection with the Carnarvon area.

The Volcanic Rocks of Springsure and The Nature, Occurrence, and Origin of Alunogen at Vandyke near Springsure, Q., by H. C. Richards, D.Sc., Proc. Roy. Soc. of Q., vol. xxx., Nos. 14 and 15, are also of interest. In general the present writer agrees with Prof. Richards in his deductions from the observations which he made in the Springsure district, although he considers that there is a likelihood of the lower andesitic lavas being Permo-Carboniferous.

Dr. Walkom's researches on fossil plants (Geol. Surv. of Q. Publications 252, 262, 257) have also been of great value in the work of compiling this report.

In the general discussion the works which have been of particular value as bearing on the Artesian question are—

Problems of Artesian Water Supply of Australia, by F. Pittman, Jour. and Proc. Roy. Soc. of N.S.W., vol. xli., 1907.

The Dead Heart of Australia, by Prof. J. W. Gregory.

The Flowing Wells of Central Australia, by Prof. J. W. Gregory.

Our Artesian Waters, by R. S. Symmonds.

The Flowing Wells of Western Queensland, by Dr. J. Grist. Richert, Proc. Roy. Geog. Soc. of Australasia. vols. xxxiv., xxxv.

The Tables of Artesian Bores, Perennial Springs, and Water Analyses published by the Hydraulic Engineer's Dept. of Q. have been particularly valuable.

III.—SUMMARY OF GEOLOGICAL RESULTS ARRIVED AT DURING THE INVESTIGATION.

1. The Geological Sequence in the Carnarvons.

The entire area examined by the writer is for the sake of convenience referred to as the Carnarvons. The rocks represented in the area include volcanics, plutonics, and sedimentary rocks ranging from metamorphic to recent. The igneous rocks (volcanic rocks) of the Carnarvon Range, Dividing Range, and Springsure areas are chiefly Tertiary, the only other volcanics noted being those of Lower Bowen and Star age, together with some tuffy sedimentaries in the Ipswich Series.

The oldest sedimentary rocks are metamorphic schists and serpentines of undetermined (perhaps Devonian) age, outcropping over a few small isolated areas as buried pinnacles recently exposed by denudation.

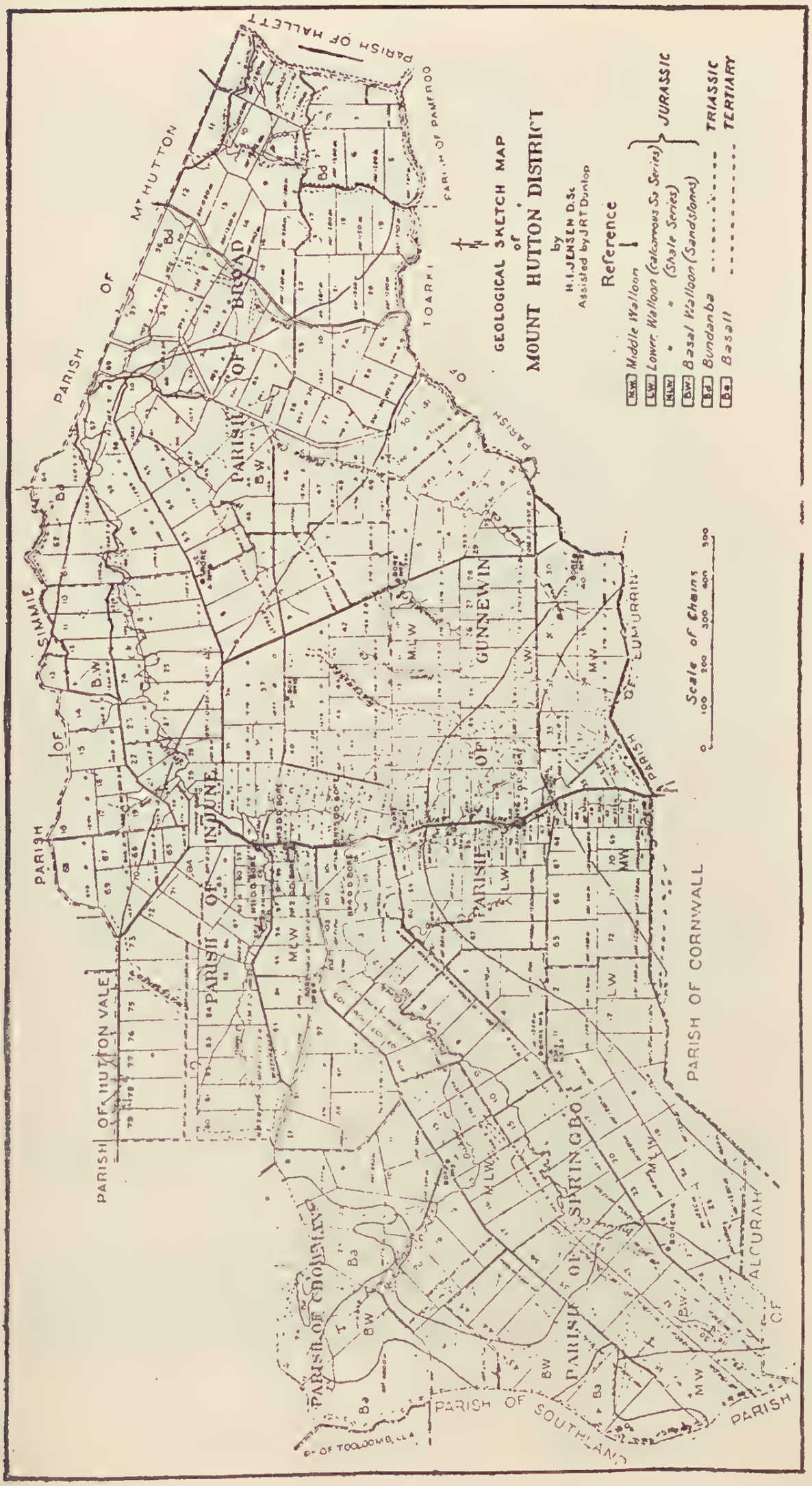
The next rocks in point of age are the Star formation, which are taken to be Lower Carboniferous ranging to Middle Carboniferous. The Lower Star rocks are sandstones with abundant *Lepidodendron veltheimianum* and interbedded basic lavas.

At Mount Budge, Drummond Range, a specimen of *Aneimites austrina* has been obtained, and the higher Star Beds are mudstones and shales of marine origin with abundant fish remains. The Star Beds are considerably folded, and are the equivalents of the Burindi Series in N.S.W.

Lying unconformably on the Star Beds we have the Lower Bowens, outcropping along the Nogoa River from Nandowrie Peak to Springsure. They consist of conglomerates largely glacial, tillites, shales (including some highly contorted varve shales), volcanic rocks (both basic and acid, with abundant prehnite and other zeolite), and forming the top of the formation we have a limestone containing an abundant fauna including *Eurydesma hobartense*. These rocks are perhaps the equivalents of the Kuttung Series.

Conformably resting on the Lower Bowens we have the Middle Bowen consisting of a lower conglomerate sandstone, a middle formation of shales with important coal measures (Consuelo Measures), and an upper sandstone with frequent red ferruginous sandstone bands. The coal beds and shales contain both Glossopteris and *Gangamopteris cyclopteroides*. The Middle Bowens fringe the Lower Bowens on the south and were traced with an approximate east-west strike and general southerly dip at gentle angles, from Blue Hills to near Springsure.

South of the Middle Bowen Series and lying conformably on them we have the Upper Bowens consisting of basal limestones, overlain by coal measures, with fine coal and kerosene shale seams, these again overlain by shales containing a rich flora of Glossopteris and *Gangamopteris angustifolia*, and then a sandstone formation (the Clematis Sandstone) which passes upwards into the basal micaceous sandstones of the Ipswich formation. The top stages of the Upper Bowen, as well as the basal strata of the Ipswich, contain abundant stems of Schizoneura, Neocalamites, Phyllotheca, and other Equisetales, which seem to be also very abundant in the Tolmies-Clermont Coal Series, and are rather characteristic of the passage beds between the Permian and Triassic. The Clematis series, lying between the Upper Bowens or Ipswich Beds, are apparently equivalents of the Borallon Series, Brisbane Valley, and are Lower Triassic.


GEOLOGICAL SKETCH MAP
of
MOUNT HUTTON DISTRICT
by
H. I. JENSEN D.Sc.
Assisted by J.R.T. Dunlop
Reference
Middle Walloon
Lower Walloon (Calcareous Ss Series)
" " (Shale Series)
Basal Walloon (Sandstone)
Bundamba
Basalt
JURASSIC
TRIASSIC
TERTIARY
Scale of Chains
PARISH OF HALLETT
PARISH OF MT HUTTON
PARISH OF BROAD
PARISH OF GUNNEWIN
PARISH OF SIMMIE
PARISH OF INJUNE
PARISH OF HUTTON VALE
PARISH OF CORNWALL
PARISH OF SIRINGO
PARISH OF SOUTHLAND
PARISH OF TOOLOOMBILLA

The Ipswich Series consists of the basal micaceous sandstones over which we find a thickness of freshwater limestones with abundant Schizoneura and then tuffs, shales, and sandstones intercalated. The tuffs are often olive green and the shales in part chocolate-coloured. They contain abundant remains of Equisetales and of *Thinnfeldia odontopteroides*. Some of the beds are very similar to the chocolate shales of the Narrabeen Series of N.S.W.

Overlying the Ipswich formation conformably, but commencing with a coarse conglomerate, we have the Bundamba formation, which is lithologically similar to the Hawkesbury sandstone and is, in the writer's opinion, the equivalent in age of that well-known Sydney formation.

Above the Bundamba and conformably resting on it we have the Walloon Series, divisible to the north of Roma into (i.) a basal, felspathic sandstone, (ii.) a highly calcareous fresh and brackish water formation consisting of limestones, shales, calcareous sandstones, coals, and kerosene shales, then (iii.) a thick sandstone, then (iv.) more calcareous sandstone, sandstone, felspathic shales, and carbonaceous beds closely interlaminated forming the Orallo Coal Measures, then (v.) more shales and sandstones with minor inferior coal-seams to the top.

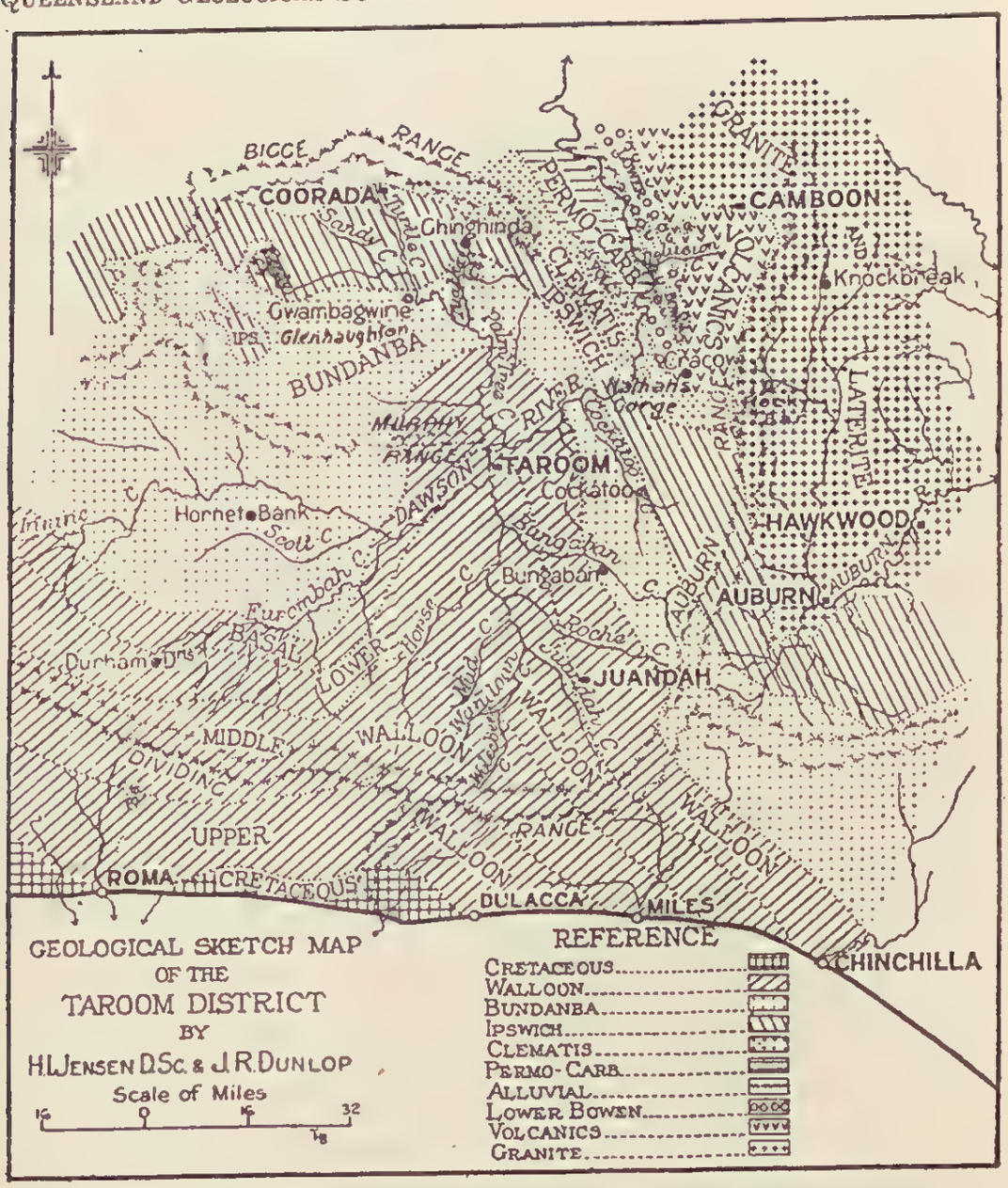
The Walloon formations north of Roma have yielded no Thinnfeldias and no large Tæniopteridæ. *Cladophebis australis*, *Tæniopteris spathulata*, *Otozamites Feistmanteli*, and *Sphenopteris superba* were the principal fossils found in the Walloon in this area, the only others being fragments of Neocalamites and other Equisetales, *Ptilophyllum pecten*, *Dictyophyllum Davidi*, and seeds and spores.

The Walloon formations are Jurassic and are probably the equivalents of the Upper Clarence in N.S.W., and of the formations met with by the writer west of the Nandewar Mountains and Warrumbungle Mountains in N.S.W. Gilgai country like that in the Narrabri corner of the Pilliga Scrub, N.S.W., is one of the features of Lower Walloon physiography. Mound springs occur in the upper part of the Bundamba at Mount Hutton, Timor, and Crystal Brook, and are comparable to the mound springs in the Pilliga Scrub, N.S.W. The plains country commencing west of the Nandewar Mountains is of the Queensland Walloon type, and the Walloon formations probably swing west through the northern edge of the Pilliga Scrub, then south-west through the western rim of the Pilliga Scrub, and thence south to Tundebrine and Tenandra.

Overlying the Walloons conformably we have the Lower Cretaceous (Cretaceous Marine), the basal beds of which are exceedingly rich in fossil wood, often toredo-bored, mixed with marine shells. It is at the top of the Marine Series we get the first marked unconformity since the inception of the Lower Bowen.

On the Marine Cretaceous we have the Cretaceo-Tertiary (Desert Sandstone) lying unconformably and horizontally stratified. The Cretaceous Marine is gently folded after the same manner as the Walloon, as described in the "Queensland Government Mining Journal," August 1920, into gentle anticlines on the direction of general dip, and terraces on the direction of general strike.

QUEENSLAND GEOLOGICAL SURVEY. PLATE III.



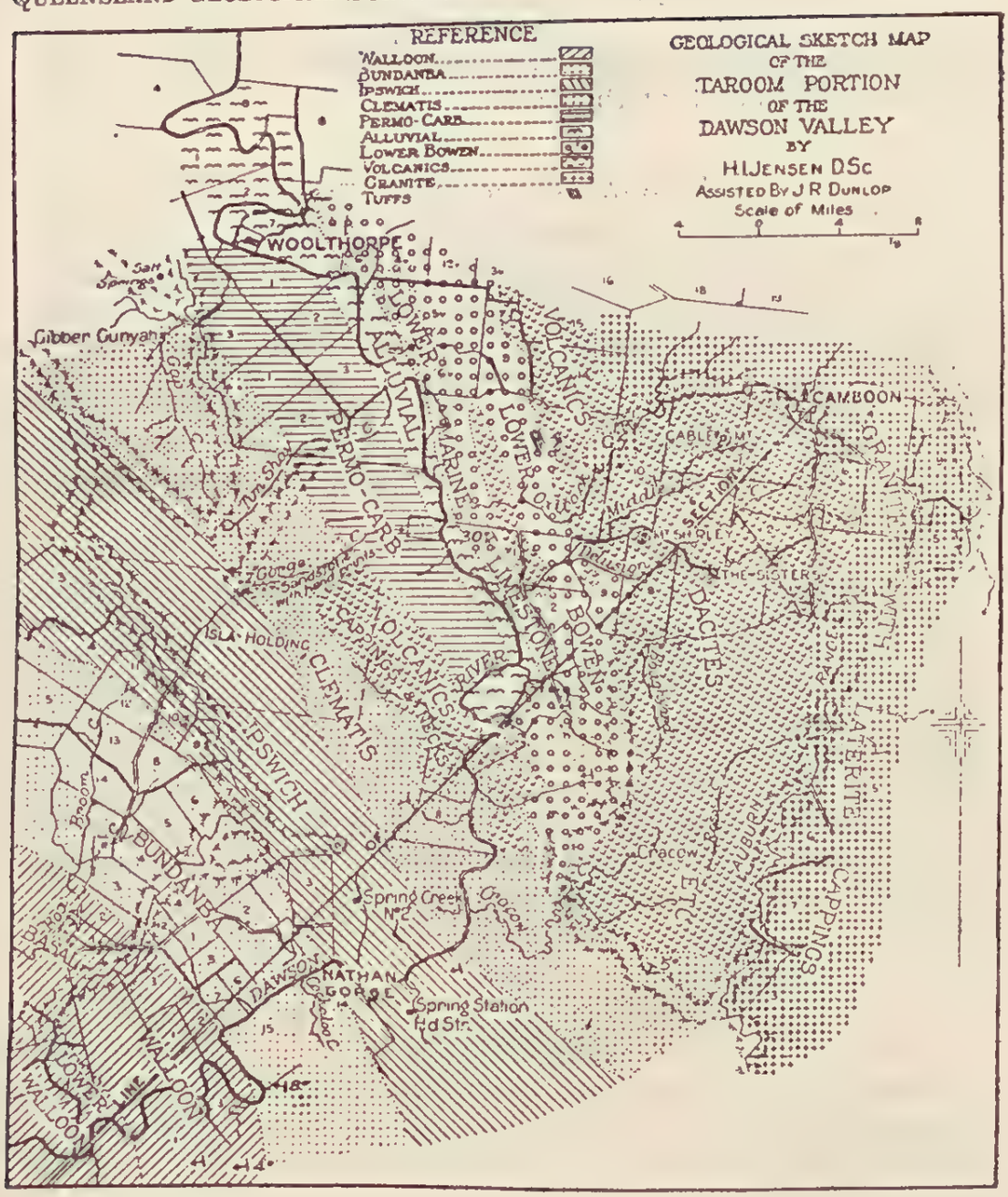
2. The Bowen Formations in the Type District.

On a subsequent journey from Mount Coolon to Bowen, the writer noticed a strong development of dacites, felsites, rhyolites, and porphyries apparently of Upper Devonian (?) age at the head of the Suttor River, a tributary of the Burdekin. These volcanics are lithologically the equivalents of the Snowy River porphyries and the Macedon dacites. In age they are probably Devonian.

The Bowen formations in the type district lie in a synclinal basin having its centre near Havilah Station, the Lower Bowen formations outcropping near the edge of the basin. The coal now being developed at the Bowen Coalfield is a Glossopteris-bearing freshwater series, overlying a series of boulder beds and conglomerates interbedded with sandstones and volcanics, and underlying the lower of *the two marine* formations described by Dr. Jack* in his Middle Bowen Series. The marine limestones overlying the Bowen Coalfield (Collinsville) coal measures are lithologically and in general fossil assemblage very like the Dilly limestone (Lower Bowen) north of Springsure. The marine limestone at Pelican Creek (Bowen Coalfield) is immediately underlain by a glacial bed with facetted boulders, and right in the marine limestones we have huge granite erratics carried by floating ice and dropped in the midst of delicate fossil organisms. Dr. Jack in his original description of the field noticed these strong evidences of glacial action. The evidence of glaciation below and within the marine limestones, both at Dilly and Pelican Creek, confirms the belief that we are dealing with the same geological horizon and that Eurydesma will be found in the Pelican Creek limestones. This is also supported by the Carboniferous affinities of the fossils in each of the two localities. Thus the Pelican Creek limestone contains *inter alia* abundant *Productus cora, Productus subquadratus, Stenopora australis, Protoretepora ampla* var. *Woodsii.* Of these, all except *Productus cora* have also been recorded from Dilly near Springsure, and *Productus cora* has been recorded by Mr. B. Dunstan *inter alia* from limestone lying west of China Bluff, Dawson Valley, a limestone formation which Mr. Dunstan found continuous with "Gympie" limestone (*see* p. 8, Geology of the Dawson and Mackenzie Rivers, &c., Q.G.S.P. 155, 1901). These fossils serve to bring together the Lower Marine of Dilly, the Lower Marine of the Dawson-Mackenzie area, and the Lower Marine of the type district, and show that this marine series is Upper Kuttung or Lower Uralian, and that the Bowen coal is a carboniferous coal, lower than the Greta. The Bowen (Collinsville) coal is practically of an interglacial age.

In the type district the coal-seams corresponding in position to the Greta of N.S.W., the Consuelo coal of the Carnarvons, the Bluff and Dawson coals in the Dawson-Mackenzie area, is apparently the "Daintree" seam and the associated series which lie above the Lower Marine. In the freshwater series between the Lower and Upper Marine horizons on the type field, Glossopteris and *Gangamopteris cyclopteroides* with Sphenopteris, *Cladophlebis Roylii,* and Phyllotheca were very abundant.

* Preliminary Report on the Bowen Coal Field, by R. L. Jack, 1879. *See* also Geology of Queensland, by Jack & Etheridge.



3. GLACIATION AND FOLDING.

The period of maximum glaciation in Queensland when the numerous thick boulder beds of the Lower Bowen were deposited was the period of great movements of folding, and was a period immediately following an age of great granitic intrusions.

On palæontological evidence the author regards the glacial period as Upper Carboniferous, and the last period of granitic intrusions in palæozoic times as Middle or Lower Carboniferous. This holds for the Carnarvons, Clermont, Mount Coolon, the Drummond Range, and other parts of Central Queensland, and probably for the Mackay-Bowen districts and North Queensland generally. Thus in the Chillagoe-Herberton area the newer granites are later than the Devonian Hodgkinson Series, but earlier than the undisturbed Permo-Carboniferous Mulligan Series.

The principal period of intense folding and mineralisation in Queensland was the Lower to Middle Carboniferous, though the processes appear to have been a little later in South Queensland than in the north of the State.

4. Absence of Glacial Evidence in the Middle and Upper Bowen.

On the writer's many traverses across the Bowen strata in the Carnarvons he failed to see anywhere any sign of a glacial formation equivalent to the Branxton. There was no evidence of any glaciation later than the Lower Bowen. Considerable importance must therefore be attached to the glacial series. They should be a more definite landmark in time than the evidence of more or less incomplete palæontological collections.

Shell-banks vary in the content of living species in different places on any modern shore-line. So they did in all ages. Until exhaustive palæontological collections have been made, judgment passed on the age of beds on such fossil collections is likely to be weakly founded, especially in an area like the Bowen Coalfield where two marine series exist, and the fossils have in many cases become mixed, and fieldwork has not yet definitely delineated which limestone the fossil locality belongs to. The Pelican Creek limestone has, however, been definitely determined to be the Lower Marine of the field as described by Dr. Jack.

5. Gangamopteris and Glossopteris of Wider Range than Supposed.

The Lower Bowen top limestone horizon being, on the strength of glacial evidence, probably the equivalent of the Dilly-Springsure horizon, and the Dilly fossils being accompanied by Eurydesma, we see that the Bowen coals are possibly Upper Carboniferous, and it follows that Glossopteris may commence in the Carboniferous. It is equally interesting to note that *Gangamopteris cyclopteroides* is very abundant in the Middle Bowens and *G. angustifolia* in the Upper Bowens. In this connection it is interesting to note that Dr. Woodward found Glossopteris in the Beacon Sandstones of Antarctica, which also contain Devonian fish remains.

6 Stratigraphical Sequence.

The following table has been constructed to show the stratigraphical sequence and thickness of the beds examined, the equivalents in other geologically examined parts of Queensland, the N.S.W. equivalents, and the type fossils.

7. Afterword.

It will be noticed that the Bowen formations have been dealt with in this paper in the original sense, this being more in harmony with observed facts in the Carnarvon area than the classification of the Bowen formations adopted by Mr. Dunstan in his Dawson-Mackenzie report.* Mr. Dunstan, as was pointed out by Mr. Cameron† in Q.G.S.P., has varied from Dr. Jack in speaking of a Lower Bowen consisting of Lower Marine, overlain by Lower Freshwater (Coal Measures), then Upper Marine and Upper Freshwater. This group of formations was bracketed as Lower Bowen, and the Clermont-Tolmies Coal Measures were classed as Upper Bowen, the Middle Bowen of Dr. Jack not being recognised.

The present writer has varied from Dr. Jack's conception of the Bowens only in one particular. Finding that the Upper and Lower Marine limestones are only comparatively thin formations—the one lying between the Lower and Middle formation, the other between the Middle and Upper Bowen—it was deemed advisable to put the Lower Marine into the Lower Bowen series where it also fits naturally on glacial evidence, and to put the Upper Marine into the Upper Bowen (Permian) where it fits well on account of the abundance of Strophalosia.

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* The Central Queensland Dawson-Mackenzie Measures, by B. Dunstan, Q.G.S.P. 155 (1901).

† The Central Queensland Dawson-Mackenzie Measures in the Mackay and Nebo Districts, by W. E. Cameron, Q.G.S.P. 200 (1905).

TABLE OF GEOLOGICAL SUCCESSION IN THE CARNARVON AREA.

Formation.	Approximate Thickness.	Other Equivalent Queensland Beds.	Equivalents, N.S.W. Formation.	Notes.	Type Fossils of Series.
Cretaceo-Tertiary—Unconformity ..	?	Desert Sandstone ..	Upper Cretaceous ..	..	None except petrified wood. Unios out west.
Marine Cretaceous	2,000 ft. and over	Rolling Downs; Maryborough Beds	Marine Cretaceous ..	The sandstones forming the artesian intake in North Queensland are Upper Walloon passing into Maryborough Beds (Croydon Beds)	*Maccoyella Barclayi*, *Fossilunula Clarkii*, Belemnites, &c.
Walloon (Jurassic)— Upper Walloon (with coal) .. Orallo Coal Measures .. Big Sandstone .. .. Calcareous (Injune Creek) .. Basal Sandstone	5,000 ft.	Rosewood and Darling Downs	1. Upper Clarence .. 2. North-Western New South Wales, rim of artesian basin	The Marburg beds of the Rosewood district seem to be equivalent of basal sandstone, Injune district; and the Rosewood beds of the Calcareous (Injune)	*Cladophlebis australis*, *Tæniopteris spathulata*
Bundamba (Upper Triassic)	Between 3,000 and 5,000 ft.	Bundamba-Ipswich Coal Field	Hawkesbury; Middle Clarence ?		
Ipswich (Middle Triassic)— 1. Upper shales and tuffs, 2,000 ft. 2. Lower micaceous sandstones, 2,000 ft.	4,000 ft.	Ipswich Coal Measures; Callide Coal Measures (?); Esk-Biarra Series	Narrabeen; Lower Clarence ?	The Esk-Biarra Series may include the Bundamba in part	*Thinnfeldia odontopteroides*, *Neocalamites carreri*, *N. horensis*, Equisetites, Schizoneura
Clematis Sandstone, Lower Trias (Permo-Trias)— Silicious sandstones passing downwards into tuffs, breccias, and in the Dawson area dacite lavas	2,200 ft.	Borallon Series, Brisbane Valley	..	..	None in this area, but Messrs. Morton and Dunlop found abundant fossils in the Brisbane Valley

Permian (Upper Bowen)— (*a*) Shales and brownish sandstones and mudstones, 2,200 ft. (*b*) Coal Measures, 1,200 ft. (*c*) Upper Marine limestone, 450 ft.	4,000 ft. ; . .	Tolmies Series (?); Havilah and McArthur Coals, Bowen River	Newcastle stage, 1,150 ft. Dempsey Stage, 2,000 ft. Tomago Coal Stage, 1,000 ft. Crinoidal shales, 2,600 ft.	Kerosene shales and Torbanites in both N.S.W. and Queensland	Crinoids, *Strophalosia Clarkii*, *Productus brachythærus*, *Saphrentis trachypora*, &c., in the main e Glossopteris, *Gangamopteris angustifolia*, and Spheropteris in the fresh water
Middle Bowen (Lower Permian to Uralian)— (*a*) Upper sandstone, ferruginous, 2,000 to 4,500 ft. ? (*b*) Coal Measures, 1,800 ft. (*c*) Lower sandstone conglomerate, 6,000 ft.	10,000 ft. ? . .	Mr. Dunstan's Lower Freshwater, Dawson-Mackenzie Valley	(*a*) Upper Marine, 3,400 ft. (*b*) Greta Coal Measures, 300 ft. (*c*) Ravensfield sandstone	Freshwater series with Daintree coal seam between Lower Marine and Marine band in Freshwater beds of Bowen Field (Jack)	Glossopteris several species, *Gangamopteris cyclopteroides*, *Sphenopteris delicula*, *Cladophlebis Roylii*, &c.
Lower Bowen (Upper Carboniferous)— Marine limestone with erratics, conglomerates, interbedded rhyolites, and basalts	7,000 ft. ? . .	Lower Marine, Dawson-Mackenzie ; Lower Marine, Bowen Field ; Lower Bowen, Bowen field ; Gympie in part	Lower Marine and Brandon Conglomerate (Uralian and Kuttung)	. .	*Eurydesma cordata*, *Productus subquadratus*, *P. cora*, *P. brachythærus*, *Aviculopecten Mitchelli*, *Rhombipora*. *Stenopora gympiensis*, *S. australis*, &c.
Unconformity— Star Beds (Middle and Lower Carboniferous)— Upper beds with fish remains Middle Beds with plant remains Lower sandstones and basic lavas	? Perhaps 3,000 ft.	Gympie and Star, various districts	Burindi Series	. .	*Lepidodendron veltheimianum*, *Aneimites austrina*, Asterocalamites, &c.

PART B.—GEOLOGY OF THE COUNTRY NORTH OF ROMA.

I.—MAPS AND SECTIONS.

The general geological map, Plate I., shows the geological formations as closely as it is possible to delineate them in country very barren in rock outcrops. The boundary between the Cretaceous and Upper Walloon was mapped by Messrs. Saint-Smith and Thom, from Yeulba Creek to Roma, and their work has been plotted on our map without alteration.

Our Walloon rocks we have divided into four stages—the Upper, Middle, Lower, and Basal Walloons. The Upper Walloon (UW) consists of fine-grained porous sandstones and interbedded shales. It contains a few coal-seams, and has a conglomerate bed at its base. The Middle Walloon (MW) consists also of sandstones and shales, but coal-seams are more frequent. Below this comes a big sandstone series between 400 and 500 ft. in thickness. The sandstone is felspathic and calcareous, and below the Big Sandstone we have the Calcareous Walloon (CW), a thick series of alternating calcareous sandstones, mudstones, and shales with frequent coal-seams. The Basal Walloon (BW) consists mainly of sandstone of a rather felspathic character. At its base there is a conglomerate which marks the transition to the Bundamba beds. In the areas adjoining the Maranoa covering the western third of the map, a Cretaceo-Tertiary (?) desert sandstone covers large areas, and basalt flows overlie other areas, causing much confusion.

The special map of the Mount Hutton Area (Plate II.) is not absolutely exact. To traverse boundaries would take too much time without adding much to accuracy. Owing to the low dips, each of the later formations runs back northwards much further in the hills or divides them in the creek valleys. We have preferred to show the average boundary—i.e., the position which the boundary would occupy if the country was level, because the construction of highly wavy boundary lines would give a suggestion of detail work which has not been done.

Fig. 1.—A geological section from Roma to the Carnarvon Range facilitates a quick comparison between the section obtained by observation of outcrops with that obtained in the sinking of the Roma bores.

Fig. 2 illustrates the nature of the country between Mount Byan Byan and Mount Hutton.

Fig. 3 gives the reader some idea of the geological structure on a nearly north-south line through Mount Hutton. It explains the nature of the volcanic masses.

Fig. 4 is an ideal section from Mount Byan Byan to the neighbourhood of Gunnewin on the Injune line, showing the probable nature of the fault (the Amby-Serecold fault) with downthrow to the west.

NOTE.—In figures 2, 3, and 4 the hatching is used to distinguish between horizons and does not indicate dip. It should be understood that the sedimentary formations are conformable. The lines bounding the horizons therefore alone indicate direction of dip.

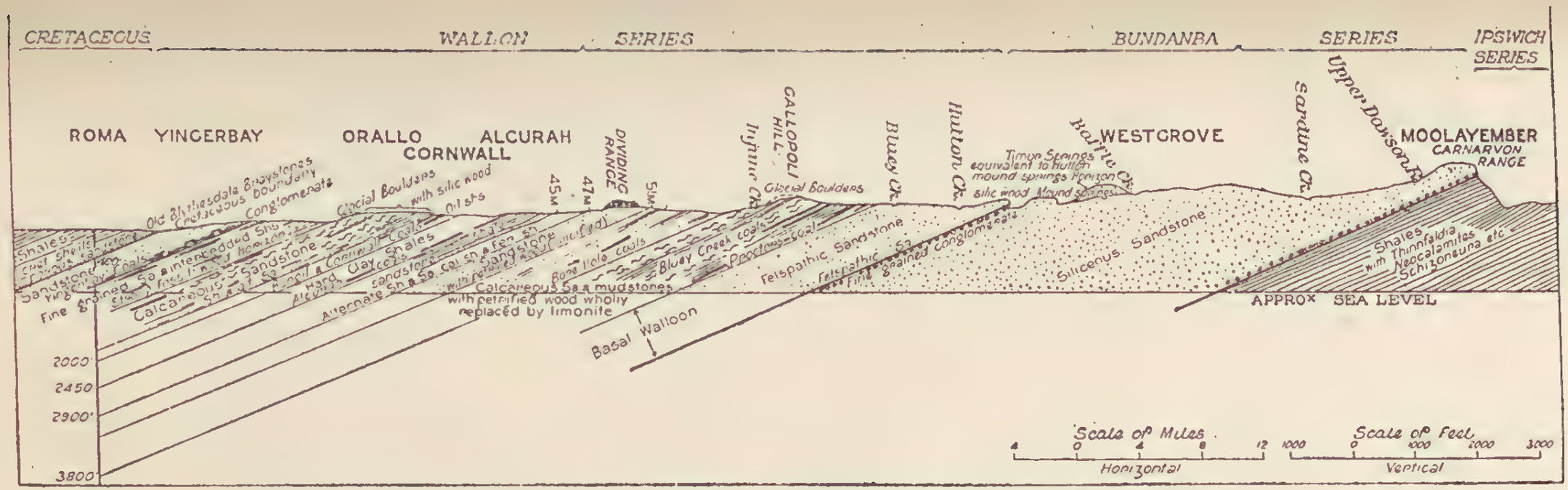


FIG. 1.—Ideal Section from Roma north through Orallo to the Moolayamber River.

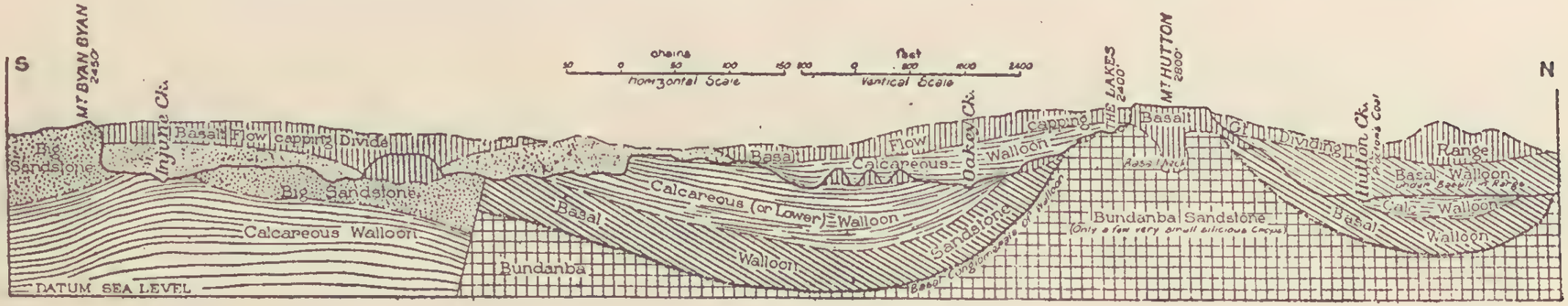


FIG. 2.—Ideal Section from Mount Byan Byan north to Hutton Creek, showing also geological formations in ranges in background.

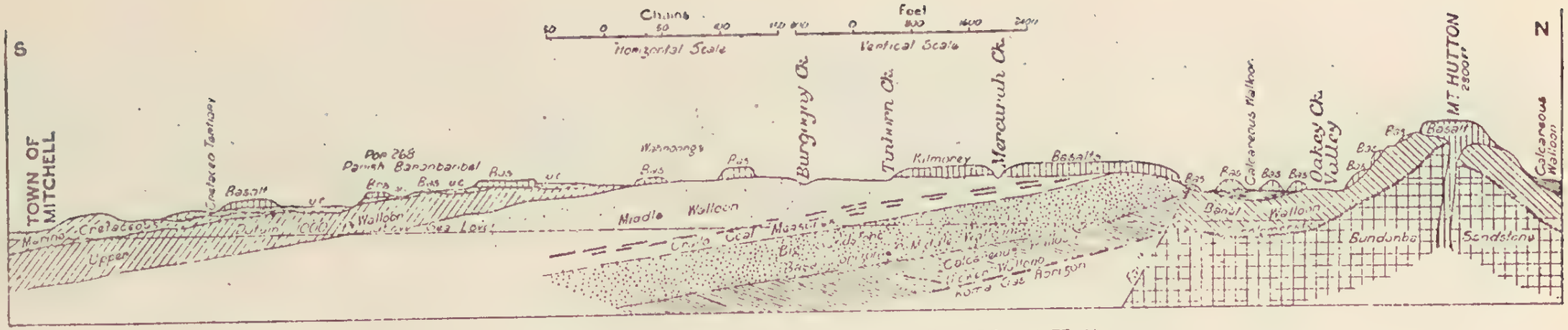


FIG. 3.—Ideal Section from the town of Mitchell to Mount Hutton.

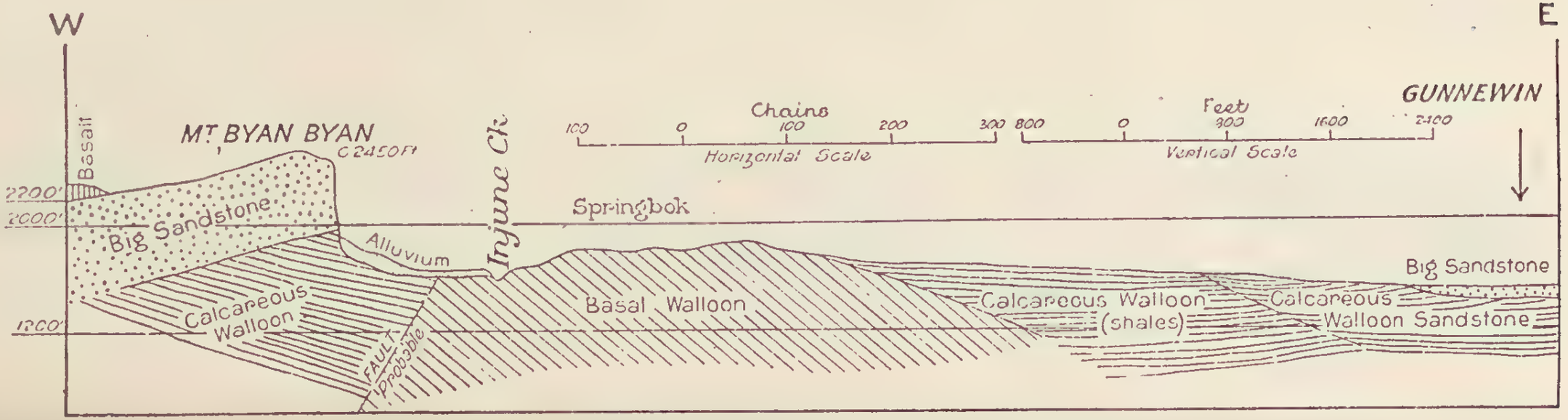


FIG. 4.—Ideal Section from Mount Byan Byan east to Gunnewin.

II.—PHYSIOGRAPHY—MOUNTAINS AND PLAINS.

Physiographically the Roma district belongs to the western plains. North-east of Roma one can see from the town a timber-clad range, Mount Bassett, about ten miles distant; this is a north-south spur from the Dividing Range.

The country which on Plate I. is coloured Cretaceous is essentially blacksoil plain as far west as Amby Creek, but west of Amby Creek and particularly in the Mitchell area there are large sandy areas which are partly derived from the disintegration of arenaceous sediments in the Marine Cretaceous and partly from sandstones of Upper Cretaceous age.

The blacksoil plain may be either untimbered or covered with brigalow-wilga-belar scrub. Some patches are very stony and bouldery, and the scrub country favours these. The sandy cretaceous soils like those of Mitchell are covered with open forest consisting of Moreton Bay ash, sugar gum (*Angophora lanceolata*), wooden-pear, oak, pine, and other timbers.

The Walloon areas lying north of the Cretaceous are much more undulating than the Cretaceous belt, a characteristic which they owe to the interbedding of shales and sandstones of varying resistance to the forces of erosion. The country north of Mitchell and around Amby is also much more undulating than the country around Roma, a fact due to the Cretaceous Marine in these parts being largely capped with remnants of basalt flows, and dabs of Cretaceo-Tertiary sandstone (UC on map, Plate I.), which are more resisting to weathering than the Calcareous Marine strata.

The Walloon belts are timbered, often scrubby. Every highly calcareous formation, whether sandstone or shale, favours the development of brigalow-belar scrubs. The belar prefers the sandy calcareous soils while the brigalow predominates on the stiff clays. The sandy Walloon belts are open forest with pine, apple, sugar gum, Moreton Bay ash, ironbark, box, &c. Very silicious sands have usually a dense pine scrub growing on them.

The country rises so gradually from Roma (about 1,000 ft. above sea-level) to the Dividing Range (about 1,400 ft.) that one hardly notices any ascent. Following the Injune railway line one crosses several elevations higher than the Dividing Range between the 36-m. and the 46-m. pegs, to the south of the Dividing Range. Likewise north of the Dividing Range in the Injune Creek Valley one meets with many detached elevations which are higher than the general divide, and generally speaking the country continues to rise in average elevation north of the Dividing Range so that the divide between Baffle Creek and Hutton Creek reaches 1,600 ft. for a considerable distance, and the Carnarvon Range further north averages 1,700 ft. with

table-hills lying on it which rise 500 to 600 ft. higher. Flat-topped sandstone table-hills are plentifully distributed around Boxvale on the Dawson River and merge into one tableland at the head of Sardine Creek, and on this tableland there are other still higher table-hills which resemble those on the Carnarvon Range. It is possible that the higher table-hills are Cretaceo-Tertiary (UC) cappings, the rock composing them being very similar in character and clad with a similar vegetation to the rocks assigned to that age near Mitchell and Amby.

Looking at the map one sees a sharp bend to the north in the Dividing Range at Kilmorey, north of Amby. The north-south run of range from this point to Mount Hutton and seven miles further north is very prominent, rising to altitudes exceeding 2,000 ft. Parts of the Mount Bassett Range also rise to heights exceeding 1,600 ft. These high elevations will be noticed to be largely basaltic. It seems as though basaltic cappings have protected much of this country from rapid erosion. The average elevation of the entire block of country lying between Amby Creek and Bottle-tree Creek on the east and the Maranoa River on the west is in general over 200 ft. higher than the elevation of the country lying east of Amby Creek. The feature is so pronounced as to suggest a strong north-south fault along this line—a suggestion which, as will be discussed later, has much to support it—yet it is quite possible to conceive that the abundant basalt flows over the western block may have afforded sufficient resistance to erosion to account for the difference in elevation.

The basalt seen in the Dividing Range, and on spurs near Mount Hutton, often forms only a capping 100 ft. in thickness, below which great sandstone cliffs can be seen. Many of the elevations like Mount Byan Byan (2,300 ft.) are purely sandstone masses without even a basalt capping. They were so massive as to be taken for Bundamba formation at first.

The basalt-capped portion of the Dividing Range is limited to the north-south stretch from Kilmorey (the V point in the range) to Hutton Vale (seven miles north of Mount Hutton). Between Westgrove and Merivale the range again becomes a low sedimentary divide until Mount Hetty is reached, where the Buckland Tableland basalt flows begin to show themselves.

Between Roma and Durham Downs the divide is, just as north of Orallo, only a low watershed. The Durham Downs country is like the Injune Creek country, composed of very calcareous Walloon rocks and is therefore mostly brigalow-belar scrub. Between Eurombah Creek and Commissioner Creek we have a very rugged area, including Pony Hills, consisting of sandstone tableland rising several hundred feet higher than Durham Downs and dissected by gorges emptying into Eurombah Creek and Commissioner Creek. From Eurombah Creek at Durham Downs, and from Hutton Creek at Mount Hutton old

head-station, sandstone country extends almost uninterruptedly to the Carnarvon Range. While it is not so dissected as at Pony Hills, on Westgrove we nevertheless get Baffle Creek, Sardine Creek, and the Dawson River running mostly in gorge-like beds between sandstone walls.

Wild gorge country becomes very abundant north of the Carnarvon Range, because here we have the tributaries of the Comet carving into the soft shales which underlie the Bundamba sandstones. The creek valleys are steep V-shaped gullies with high sandstone cliffs surmounting the steep slopes (*see* fig. 11, page 106).

The country north of Mitchell is more hilly than that north of Roma as far as Forest Vale. From that station northward the rise of elevation is as gradual as it is north of Roma. Indeed travelling over gentle undulations one hardly notices the gradual rise from a level of 1,250 ft. to one of 2,000 on Crystalbrook. The plateau nature of Crystalbrook and Eddystone Vale Stations is, however, well shown by the canyon in which the Maranoa flows at and above Eddystone Vale. Massive sandstone walls line both banks.

Elevations.

The following table used in conjunction with Plate I. will serve to give some idea of the contours:—

Height of Railway Sidings as kindly supplied by the Railway Engineer's Department.

	Ft.		Ft.
Roma	979	Orallo	1,200
Ona Ona ..	1,055	Hunterton ..	1,282
Minka	1,050	38-mile	1,424
Euthulla ..	1,061	45-mile	1,368
Nullawurt ..	1,029	Gunnewin ..	1,363
Yingerbay ..	1,047	Komine	1,293
Nareeten ..	1,093	58-mile	1,278
Oogara	1,255	Injune	1,264
Eumine	1,170		

The height of the Dividing Range at the 49-mile is given as 1,465 ft., and the following additional information from railway surveys shows that the highest point on the Orallo railway is right off the Dividing Range (the 45-mile):—

	Ft.
43-mile	1,387
42-mile	1,459
39¾-mile	1,536

The following heights are approximate only, calculated from aneroid observations:—

Dividing Range near Mooga (Durham Downs road), 1,300 ft.;

Franksvale Creek (Durham Downs road), 1,150 ft.;

Eurombah Creek (Durham Downs), 1,000 ft.;

Eurombah Creek, 3 miles above Durham Downs Creek, 1,080 ft.;

Durham Downs, 1,000 ft.;

Divide between Eurombah and Scott's Creeks, 1,150 to 1,200 ft.;

Cornwall Station, 1,320 ft.;

Selection 30, parish of Springbok Camp, 1,640 ft.;

Mount Byan Byan, 2,440 ft.;

Selection 19, Oakey Creek, 1,500 ft.;

Base of Mount Hutton, 1,500 ft.; summit, 2,800 ft.;

Mount Hutton Old Homestead, 1,100 ft.;

Divide between Hutton and Baffle Creeks north of old Mount Hutton Station, 1,650 ft.;

Baffle Creek Camp, 1,400 ft.;

Dawson River Camp (Boxvale), 1,400 ft.;

Jack's Mountain, 2,100 ft.;

Spring Creek, 1,500 ft.;

Carnarvon Range, 1,700 to 2,200 ft.;

Bullaroo Creek (Moolayamber) Camp, 1,250 ft.;

Amby, 1,136 ft.; Table-hills around Amby, about 1,250 ft.;

Taboonbay (old hotel site), 1,300 ft. approximately;

Amby Resumption, 1,400 to 1,500 ft.;

Wahroonga, 1,400 ft.;

Campbell's Dam on Long Gully (Burgogay Creek), 1,700 ft.;

Sandstone Table-hills at head of Long Gully, 1,900 ft.;

Southlands, 1,800 to 2,000 ft.;

Mount Kennedy, 2,200 ft.;

Toolumbilla Station, 1,600 to 1,800 ft.;

Forest Vale, 1,250 ft. at river to 1,500 ft.;

Mount Bindango, about 1,800 ft.;

Desert sandstone hills around Wahroonga and at head of Basalt Creek and Back Creek, 1,400 to 1,500 ft., with basalt hills 6 to 10 miles north of Wahroonga, 1,700 to 1,900 ft.;

Sandstone spinifex country, 14 to 17 miles north of Mitchell, 1,400 ft.;

Simpson Creek Camping Reserve, 1,500 ft.;

Divide between head of Simpson Creek and the Maranoa at Eddystone Vale, 2,100 ft.;

Bundara Creek at Crystalbrook, 1,700 ft.

Mount Hutton and Mount Byan Byan.

The basalt-capped portion of the Dividing Range and of the Mount Hutton spur is extremely rugged. Mural escarpments of sandstone capped with basalt run for miles. The basalt has flowed over a very uneven surface. Within a few miles of Mount Hutton on Oakey Creek one can see basalt resting on Walloon strata at a level of 1,500 ft. On Mount Hutton near the Lakes we have basalt resting on sandstone at a level of 2,540 ft. The Lakes on Mount Hutton are not crater lakes, but seem to be due to water erosion along a joint which has afforded an underground channel of escape below the basalt and which has subsequently silted up. The Lakes are leaky and do not hold water in a drought.

From Mount Hutton a wide basaltic flow swept south-west along an old valley. The surface of this flow is seen north and west of Mount Byan Byan in the Dividing Range. It varies from blacksoil plain, well grassed and timberless, to gently undulating gum-top box country, which has a westerly drainage. The sandstone scarps underlying the eastern edge of the basalt are probably brought into their present position by a fault.

Mount Byan Byan is composed of silicious sandstone throughout. Some bands are also ferruginous. The vegetation is of the bad lands type—ironbark (*E. decorticans*), wattle scrub, yellow bloodwood, and calythrix brush. South of Mount Byan Byan we have a cone, which we call Kilmorey Pinnacle, which consists of basalt, a dyke intrusion, and highly disturbed sandstone. There must have been a focus of eruption in the vicinity, for on the little plain south-west of the Pinnacle there are fragments of quartz porphyry, greisen, slate, and chert, foreign to the district, scattered about on the soil, with wood opal, common opal, and other rocks indicating the products of weathering of the ejacamenta from a volcano. We were informed by a resident of the district that a huge granite boulder weighing many tons occurs in the basalt on one of the Kilmorey hills. Obviously there is granite underlying the sedimentary rocks of the district.

Arcadia Valley and the Lynd Range.

We did not proceed far into Arcadia Valley. However, looking across this valley and the Lynd Range we see nothing but canyon scenery of the Blue Mountains (N.S.W.) type. The canyons are carved in massive sandstone and the vegetation in

the beds of the gorges indicates that the Bundamba sandstones here are underlain by Ipswich shales as in the Moolayamber Creek gorge. The sandstone tableland which has been dissected by these canyons averages 2,000 ft. in altitude while the gorges have been cut down to 1,200 ft. The upper 400 ft. of the canyon walls usually form sheer cliffs of beautiful white or slightly pinkish sandstone. The scenery is extremely fine, rivalling the Blue Mountains.

The Carnarvon Range has an average height of 1,700 ft. at the gaps but is capped at intervals by sandstone mesas rising to 2,200 ft. The fall into the Moolayamber Creek is precipitous at most points, and at the gaps exceedingly steep and almost unnegotiable even with packhorses. The sandstones on this range have the usual sandstone flora—stringybark, stringybark messmate, ironbark, &c.—but the steep slopes of Ipswich shales underlying the sandstone support principally spotted gum and zamia. The timber is magnificent and the scenery wild in the extreme.

Rivers.

The rivers and creeks of the area under review comprise the east-flowing branches of the Dawson north of the Dividing Range and the south-flowing branches of the Maranoa and Condamine south and west of the Dividing Range. Owing to the flatness of the country and the great depth of soil, these rivers and tributaries flow through the plains in shallow, U-shaped gutter-like channels from which the water overflows the plain on both sides in wet seasons. The two banks of a river or creek are frequently considerably higher than the plain country on either side, being raised by the repeated piling of detritus there in small floods. That characteristic is noticeable in Injune Creek where the railway bridge crosses it. Rocks seldom show in the creek beds and banks where the streams flow through shaly and calcareous country: it is only when they enter sandstone regions that exposures become very frequent. Throughout the area coloured Bundamba on the map the creeks are dominantly rocky.

The Maranoa River and its tributaries have carved mighty gorges in the higher reaches at and above Eddystone Vale. Likewise the Merivale and its tributaries flow in gorges above Crystalbrook Station. Inasmuch as the elevation of the country is about 2,000 ft., and of the bed of the Maranoa at Eddystone Vale about 1,700 ft., there is a fall of 500 ft. in the river between this and Forest Vale. The river above Eddystone has a considerable catchment, and the valley carved between the sandstone cliffs is many hundred yards wide, frequently over a quarter of a mile. The country along the Maranoa below the junction with the Merivale is mostly a rich sandy loam ideally suited for irrigation. Nothing is surer than this: That if irrigation

can be applied in the Maranoa by locking the river at Eddystone Vale the district will be one of the greatest producing areas in Australia.

North of the Carnarvon Range the headwaters of the Comet have cut through the Bundamba sandstones into the underlying calcareous shales of Ipswich age, with the result that most magnificent canyon scenery has developed. For scenic beauty the Moolayamber Gorge and Arcadia Valley beat anything in the Blue Mountains of New South Wales.

The Soils and Vegetation.

The Roma plains are so extensively covered with alluvium that the soils are mostly of mixed origin, constituting rich calcareous clays and adobes. Much of the plain is timberless, but other parts are timbered with patches of whipstick brigalow, myall, sandalwood, wilga, whitewood, emu apple, and belar. Other parts again constitute open forest of broadleaf box and silverleaf ironbark. Very sandy parts are covered with cypress pine. The "pear" pest is spreading rapidly wherever poisoning is neglected.

The Walloon country between Roma and Injune Creek is very variable in soil. It is less alluviated, hence the soils belong to the underlying formations, which change from sandstone to shale and calcareous rocks. The sandstone flora is typically calciphobe containing quinine, pine, oak, tumbledown gum, sugar gum, apple, Moreton Bay ash, &c., whereas the calcareous rocks have the usual calciphile flora in which brigalow, belar, and wilga figure prominently. Along the creeks, river gum (*Eucalyptus tereticornis*) and apple (*Angophora intermedia*) are always dominant.

The sandy soils of the Walloon belts are mostly good wheat soils, and many of the heavier calcareous soils like those of Injune Creek are also sufficiently friable to make good wheat land.

The Walloon areas are typical mixed farming country on which wheat-growing and sheep-raising should go hand in hand.

Sugar-gum country and thick pine scrubs constitute the poorest lands as regards plant food but are the easiest soils to work. The best loams for agricultural purposes are those which are covered with belar scrub. Thick belar without brigalow indicates a light loam rich in plant food, while brigalow scrub without belar denotes a heavy clay soil hard to work.

The interpretation of the geology of this area requiring a considerable reliance on the character of the vegetation, we collected botanical specimens, which were diagnosed and classified for us by Mr. White, Government Botanist, for whose generous help in this respect we are deeply grateful.

The Walloon country can be divided into—

(*a*) Brigalow (*Acacia harpophylla*) scrub, on heavy clay soils of shale origin. Soil rather alkaline.

(*b*) Brigalow-belar scrub (*A. harpophylla* and *Casuarina lepidophloia*), calcareous adobe soil derived usually from calcareous sandstone. The associated vegetation includes some sandalwood (*Eremophila Mitchelli*), *Canthium oleifolium, Alstonia constricta, Notolea microcarpa, Cassia eremophila* (buttercup bush), *Geijera parviflora* (wilga), *Owenia acidula* (emu-bush), *Hovea longipes, Acacia pendula* (myall), &c.

(*c*) Belar scrub (*Casuarina lepidophloia*) on sandy loams rich in plant food derived from calcareous sandstone.

(*d*) Box country with clayey soil, bad drainage, and often referred to as "sour" though more likely to be alkaline than acid. Associated with the box (*Eucalyptus populifolia*) we may get some sandalwood (*Eremophila Mitchelli*) and silverleaf ironbark (*E. melanophloia*). This class of country overlies shale.

(*e*) Ironbark (*E. melanophloia*) or silverleaf country. This extends over the more silicious and massive sandstone areas. Ironwood (*Acacia excelsa*) often accompanies the ironbark.

(*f*) Sandalwood country. This has a calcareous clay soil overlying calcareous shale. Associated with sandalwood (*Eremophila Mitchelli*) we have more or less hopbush (*Dodonea viscosa*), wilga (*Geijera parviflora*), orange (*Capparis Mitchelli*), whitewood (*Atalaya hemiglauca*), &c.

(*g*) Pine country (*Callitris robusta*); light sands poor in plant food, overlying silicious sandstones. If the sandstone contains some lime, some of the calciphile timber (*see* under *b*) are associated. In such cases it is fine wheat land, but where silverleaf ironbark is an associate the soil is usually shallow.

(*h*) Sugar gum (*Angophora lanceolata*) country. Fine, deep, sandy loams of great capillary power, but generally poor in plant food. These soils are of sandstone origin and would for cultivation require manuring.

The Bundamba Sandstone areas are characterised by poor soils and a comparative absence of calciphile trees. Brigalow, belar, and sandalwood are met with only in small, remotely isolated patches.

The dominant timbers are pine (*Callitris robusta*) and some silverleaf ironbark (*E. melanophloia*) on the hills, and in places on the Westgrove run some belts of narrowleaf ironbark

(*E. crebra*) on rising ground; but mostly box (*E. populifolia*) on the flats, associated with sugar gum (*Angophora lanceolata*) and tumbledown gum (*E. dealbata*). Wattles are abundant where the stone is near the surface, and include *Acacia decora*, *A. Cunninghamii*, and *A. macradenia*. Grevilleas and hakeas are sparingly distributed, also dogwood (*Jacksonia scoparia*) and wild cherry (*Exocarpus cupressiformes*). Quinine patches (*Petalostigma quadriloculare*) occur here and there.

Moreton Bay ash (*E. tesselaris*) occurs sparingly wherever sugar-gum country is met with, both in the Walloon and Bundamba. This timber is fairly frequent in the Orallo-Forest Vale belt of the Walloon and in the Upper Bundamba. Bloodwood (*E. corymbosa*) comes in occasionally in the Carnarvon Range, and yellow bloodwood (*E. trachyphloia*) shows up strongly wherever the sandstones (whether Bundamba or Cretaceo-Tertiary) have a barren nature. It is accompanied on very poor sandstone country by pear (*Xylomelon pyriforme*), stringybark (*E. acmenioides* ?), budgeroo (*Lysicarpus ternifolius*), and fibrous-barked oak (*Casuarina inophloia*). Such country is met with plentifully along the Dawson River below Boxvale, and is also characterised by numerous prickly bushes (*Leucopogon biflorius* and *Bossiæa rhombifolia*), reminding one of the barren Hawkesbury sandstone country in New South Wales.

Soils West of Amby Creek.

The entire area west of the longitude of Amby is on the average much more sandy than east of that line. The covering up of wide areas of Cretaceous and Walloon by a blanket of Cretaceo-Tertiary (UC) sandstone accounts for this. There is also a tendency for the Walloon strata themselves to become more sandy in this region. All the sandy soils in this area have a vegetation of much the same type as the Bundamba vegetation. Where the Cretaceo-Tertiary blanket is very silicious we get spinifex country with yellow bloodwood, sugar gum, pear, Moreton Bay ash, budgeroo, and strangle wattle (*A. macradenia*). On the massive sandstones of Middle Walloon age as on Mount Byan Byan, Mount Kennedy, and on the sandstone tablelands at the head of Burgagay Creek we have another sandstone flora in which pine is accompanied by the ironbark (*E. decorticans*), a high-altitude timber in this district occurring only at an approximate elevation of 2,000 ft. On the Upper Bundambas at Crystalbrook, hill oak (*Casuarina torulosa*) is common in parts, while at the base of the Bundamba, on the north fall of the Carnarvon Range north of Boxvale, and also at Mount Moffatt, the Ipswich shale flora, with spotted gum (*E. maculata*) and macrozamia, creeps in on the Bundamba.

The basalts of Mount Hutton and the neighbouring part of the Dividing Range have a flora of their own in which gumtop box (*E. hemiphloia*), bottle-tree (*Sterculia rupestris*),

currajong (*Sterculia diversifolia*), wattle (*Acacia decurrens* var. *mollis* and var. *dealbata* and *Acacia decora*), and numerous scrub plants play an important part.

Bottle-trees are also sparingly spread through the Walloon brigalow-belar scrubs, and currajongs are occasionally met with on any good alluvial soil.

The Prickly-pear.

This nuisance spreads with greatest rapidity on good country such as in the brigalow and belar scrubs. The destruction of the pear is a problem the solution of which depends on closer settlement, higher land values, and greater utilisation of the country for wheat culture. When the land becomes worth £10 per acre for mixed farming instead of 10s. per acre for pastoral purposes, the pear problem will solve itself.

Boulder Mounds.

Here and there throughout the Walloon belts, and in one place on the Carnarvon Range where the Boxvale-Moolayamber track crosses Spring Creek, were seen remarkable boulder mounds. Many of these attain the size of small round hills and others form long ridges like railway embankments, most strikingly suggestive of moraines. At first these were thought to be Tertiary river gravels, but the idea had to be abandoned for the following reasons:—

(1) The boulders exhibit no uniformity in size, and show not the faintest sign of river sorting.

(2) The heaps are irregularly scattered, and do not lie in such alignment that they can be regarded as the remains of river channels.

(3) Often the largest boulders are on top, and some are too large and too angular to have been transported by rivers.

Amongst other characters of these boulders should be noted the following:—(*a*) All the boulders and pebbles are highly polished; (*b*) they consist of chert, porphyry, quartzite, quartz, and a little slate, mostly rocks foreign to the surrounding sedimentary formations; (*c*) some are subangular, some rounded; (*d*) all are highly polished, some are facetted, and some crudely striated and cross-striated; (*e*) basalt was absent in the material composing the heaps; (*f*) the boulder mounds conform to no definite horizon either in the Walloon or other formations, but all lie at approximately the same elevation above sea-level—viz., between 1,300 and 1,500, averaging 1,400 ft., indicating deposition after a period of erosion following the major folding movements.

No boulder beds have been pierced in the bores of the Roma and Mitchell districts, confirming the idea that these mounds

are a Post-Cretaceous-Marine, Post-Rolling-Downs formation. In some of the Cypress Downs (south of Mitchell) bores, however, a conglomerate aggregating 38 ft. in thickness was passed through below the Tertiary or Upper Cretaceous clays and drifts.

No boulder mounds have been observed on the basalt areas, but basalt directly overlies the boulders east of Selection 19, Oakey Creek (par. Crowman). Obviously they are pre-basaltic.

The following are some important and interesting localities for these boulder mounds, with approximate elevations:—

		Ft.
(1)	Alcurah, near junction of Bungeworgorai and Alcurah Creeks	1,360
(2)	Boyd's, Selection 111, par. Injune	1,410
(3)	Gallipoli Selection 100, par. Injune	1,400
(4)	Eumamurrin Range	1,360 (?)
(5)	Hutton Creek, Johnson's Selection No. 6, par. Huttonvale	1,300
(6)	Hutton Creek, Wilkinson's Selection No. 3, par. Crowman	1,450
(7)	Spring Creek, on Boxvale-Moolayamber track	1,500
(8)	Oakey Creek, Selection 2, par. Crowman	1,450
(9)	A few miles east of Donnybrook	1,400
(10)	About 10 miles north of Forest Vale	1,400
(11)	Amby-Wahroonga road, about 8 to 11 miles north of Amby	1,400
(12)	Various places at head of Basalt Creek and Back Creek, about	1,400

No boulder mounds were seen on the Bundamba Sandstone areas north of Hutton Creek, nor at Crystalbrook. On the Cretaceous in the Roma district, gravels and boulders are thinly scattered over wide areas but form no definite mounds, whereas north of Mitchell where the elevation of the country approximates 1,300 ft. boulder mounds are common.

The vegetation usually found on these mounds consists of brigalow, wilga, turkey-bush scrub. The soil is a stony clay soil usually reddish.

A slight variation in the nature of the material was noticed. Thus in the Injune area cherts and porphyries predominated in the material, while in the areas north of Mitchell quartzite predominated.

Since the river deposit theory of origin is untenable, the following alternative theories were considered:—

(A) Origin from a formerly widespread Cretaceo-Tertiary capping of silicious chemically cemented detritus; the cementing process due either to pre-basaltic hot springs, or the capillary rise of silicious waters under arid conditions.

In favour of this theory we would have (*a*) the variation in character of boulder rock in the different areas—quartzites being roughly predominant where the country is mostly sandstone; (*b*) the occurrence of wood opal in the boulder heaps; but against the theory we have (*a*) the fact that the boulder material is not uniformly scattered but gathered together as if artificially dumped; (*b*) the material is in each instance too heterogeneous and too worn to have formed *in situ*, except in one locality, the Mount Bindango ridge. This mountain was found to be capped with a thick stratum of cherty breccia, which yields remarkable perched blocks on the lower slopes. One huge mass weighing over 20 tons, egg-shaped and glistening on its polished surface, was standing about 50 ft. below the general level of the sheet, end-on in soft Cretaceous shale. There was no transition from shale to chert; on the other hand the weight of the perched block had dinted the subjacent shale. The general sheet of cherty rhyolite breccia higher up was cracked into huge subangular blocks with the top surface more or less polished.

This Bindango breccia is more elevated than the boulder mounds and lies at probably 1,600 ft. above sea-level. It certainly seems to be an indurated volcanic breccia. From its characters it was endeavoured to build up the next theory, viz.:—

(B) Origin through fusion and cementation of underlying rocks by a former continuous basalt sheet. This theory would be supported by the same facts as theory A, and also by the fact that there are basalt dykes through Mount Bindango. The basic eruptions might thus have been preceded by breccia volcanoes throwing out rhyolitic material. The later basalts caused the cementing of the tuffs and the formation of common opal. As in the case of theory A, the erratic mode of distribution of the boulder mounds militates against this theory, and the most damaging fact against it is that both in the Injune district at Oakey Creek and in the Amby district there are boulder beds of the usual type underlying the basalts actually as boulder beds.

Again, no foci of eruption have been noticed for these breccias unless there may be one in Mount Bindango, which has a structure suggestive of a volcano. Further, in no instance has it been possible to trace a passage or transition stage between the boulder rock and the subjacent rock.

(C) *Glacial Theory.*—The only other explanation is that these boulder mounds are of glacial origin. Although in several places in the Injune valley they closely resemble moraines, the facts of their distribution suggest rather deposition by floating icebergs which became stranded on the shores of the Late Cretaceous sea. There may have been isolated islands with rhyolite cappings which were scoured by these bergs and yielded them material to dump elsewhere.

This theory explains why large areas of blacksoil plain are entirely free from boulders, while right in the midst of them are boulder patches forming little hills. The glacial theory also helps to explain the wide distribution of boulders and gravels over the Cretaceous at Roma and further west at Longreach. In the latter area granite, porphyry quartz, and topaz belonging to country hundreds of miles distant form gravel areas which are a source of mystery on our western plains.

Round Limestone Boulders.

Not to be confused with the boulder mounds are occurrences of limestone boulders, from the size of a billiard ball to several feet in diameter, in a few places on the Myall Range near the head of Eurombah Creek. These boulders are due to spheroidal weathering.

III.—GEOLOGY.

The formations encountered in the area under review may be dealt with under the following heads:—(*a*) Post-Tertiary; (*b*) Cretaceo-Tertiary; (*c*) Upper Cretaceous; (*d*) Marine Cretaceous; (*e*) Walloon (Juras); (*f*) Bundamba (U. Trias); (*g*) Ipswich (Mid. Trias).

(A) Post-Tertiary.

This consists principally of alluvium. Alluvium of fluviatile origin has spread widely over the Cretaceous plains through river floods, and it lines all the principal rivers and creeks. In the research carried out by us it had no geological importance, and therefore nothing further will be said about it. It is not shown on our maps as a separate geological formation.

(B) Tertiary.

Tertiary sediments of lacustrine origin must doubtless exist in many places under the alluvials overlying the Cretaceous, but we have not met with any outcropping on the surface. A considerable extent of calcareous yellow mudstone is met with on the Amby-Wahroonga road, eight to twelve miles north of Amby, which may possibly be Tertiary. The vegetation on

this belt is like that met with on the calcareous Walloon strata, but the area has Cretaceous Marine strata north of it and Cretaceous and later formations all around it, so that in the absence of any fossil evidence all that we can say is that it is later than the Marine Cretaceous. Lithologically the rock is very like the Tertiary mudstones on the hills around Winton.

The most important Tertiary rocks are the basalts.

The principal basalt areas are shown on the maps. There are, however, mounds, scattered basaltic tabletops, and cones in the area north of Mitchell and Amby which have been missed through being small or not on the lines of traverse. The position and distribution of the basalts in this part points to most of the country between the Dividing Range at Mount Hutton and the railway line between Amby and Mitchell having been basalt-covered at one time. The lavas did not all come from the Dividing Range, for tuffs and breccias pointing to local craters were met with in Opal Hill about half a mile south-west of Amby railway station, and highly vesicular basalts at numerous

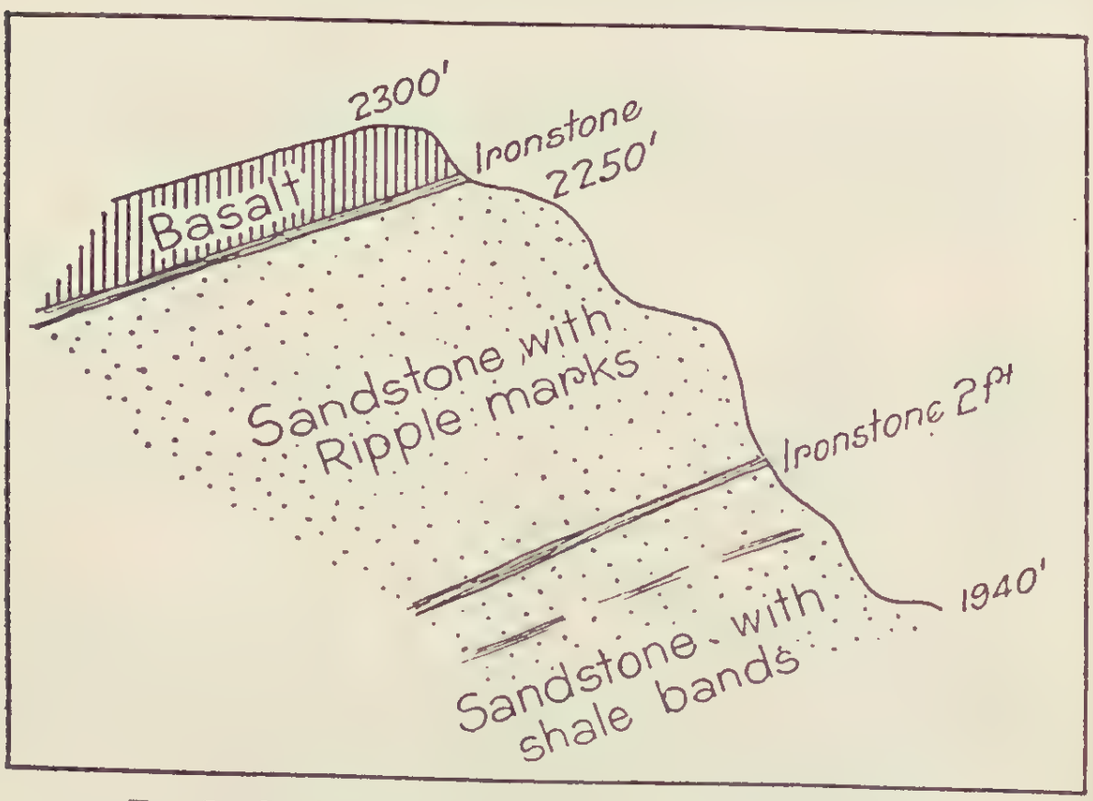


Fig. 5.—Section of Cliffs west of Kilmorey Pinnacle.

points throughout the area. It is, however, in evidence that most of the basalt forming the big patch along and west of the Dividing Range between Kilmorey and Mount Hutton came from craters near or north of Mount Hutton and flowed south-west. The floor of the basalt falls gradually as we proceed south-south-west. At Mount Byan Byan and Yellowflower it is 2,200 ft. above sea-level, at Wahroonga about 1,400, and at Amby about 1,200 ft. On Long Gully about six miles west of

Byan Byan the basalt floor is on the average at 1,900 ft. about 300 ft. lower. This means a drop of 50 ft. in the mile, which is consistent with the dip which has determined the general slope of the country prior to the basalt outflow through erosion proceeding along definite softer planes. The big Kilmorey flow followed a broad valley in a south-south-west direction which it filled to a present height of 2,250 or 2,300 ft. above sea-level. The base of the basalt west of Kilmorey Pinnacle is at 2,250 ft., the summit about 2,300 ft. It is flanked on the east by sandstone which formed a barrier on the east. Mount Byan Byan, which is a sandstone ridge in the Dividing Range on Kilmorey Station, reaches a height of 2,400 ft. and was apparently not flooded by basalt. It was part of the eastern barrier.

Nevertheless, not more than two miles east of the eastern escarpment of the Dividing Range we have basalt on Selection 40, parish Springbok, as low as 1,500 ft.; and on Oakey Creek, tributary of Injune Creek, we get it about the same elevation capping boulder mounds. It is not clear why the valleys east of the Dividing Range have only been affected by small flows. The suggestions of faulting are many, but no definite proof has been seen. Dr. Jack, in discussing the basalts of the Buckland Tableland (Annual Report 1894), says that there were in that region two series of volcanic outbursts: "The second series of outbursts is represented by the basalts, which, at least a thousand feet below the basalt of the tableland, occupy the valley of Buckland Creek, showing that an immense amount of erosion had taken place before their deposition." "Rands and Gibb Maitland regard the first basalt series as practically contemporaneous with the Desert Sandstone."

Although a similar explanation would make the lower position of the basalt east of the Dividing Range less puzzling, we can see no strong reason to ascribe the basalt to two periods.

It is quite certain that the country was considerably dissected when the basalt flows took place. There was a north-south sandstone tableland west of the Injune plain forming the present divide, reaching an altitude 900 ft. higher than the Injune country. The tableland sloped west. The flows commenced on the tableland and naturally the big flows followed its general slope.

The cause of the difference in elevation between the Injune side and the Kilmorey side of the divide before the basalt flows seems almost certainly to have been earlier faulting. The basalts may have risen partly along the old fault-line.

The Mount Bassett flow, extending to within ten miles of Roma, came down an old stream channel. The base of the basalt rests on a river gravel at an elevation of 1,380 ft. To-day the erosion of the general level east and west of Mount Bassett has reduced the elevation to 1,000 ft., while the basalt surface

is about 1,500 ft., so that about 500 ft. of erosion has probably taken place since the eruptions. This estimate is corroborated by the post-basaltic erosion at Kilmorey and other parts.

The Hutton and other basalts of the entire area under review are probably of Miocene age. They must be Early or Middle Tertiary, since erosion in the area is slow, and Late Tertiary basalts would fill in river valleys instead of capping ranges.

(c) Cretaceo-Tertiary.

Boulder Mounds.—We consider the boulder mounds Early Tertiary because they are pre-basaltic. Like the basalts they have protected underlying beds from eroding as rapidly as uncovered parts, hence occur as rises or hills. As far as can be judged at present the boulder heaps were dumped on shallows or in bays of the Cretaceo-Tertiary sea. The Kilmorey-Byan Byan sandstones, which were dry land, and the Bundamba sandstones to the north, also land, were not affected.

From the boulder mounds and basalts, together with stratigraphical observations, we can only conclude that the following processes took place:—

(1) Continuous sedimentation from the Ipswich to the end of the Marine Cretaceous period.

(2) Uplift and erosion of the Mesozoic beds already formed.

(3) Gentle folding, yielding an anticline with north-south axis from Bongo to Mount Hutton.

(4) Faulting leading to downthrow of region west of fault. The downthrown side is to-day the higher ground.

(5) Further erosion and general subsidence leading to Cretaceo-Tertiary lake- or sea-floating ice deposited boulder heaps on the shores.

(6) Re-elevation followed flooding of lower reaches of valleys with Cretaceo-Tertiary silts. Simultaneous outbursts of rhyolite tuff (?).

(7) Basalt flows down large valleys.

(8) Further dissection removing Cretaceo-Tertiary formations except where covered by boulders or basalt.

The other formations which we are tentatively classing as Upper Cretaceous or Cretaceo-Tertiary (UC on map) include the Bindango cherty breccias (rhyolitic apparently) and some brecciated sandstones and mudstones (formerly regarded as trachytic) typically developed in the railway cuttings just east of Amby. These sandstones and mudstones, if completely silicified by hot-spring action into chert, would not be very dissimilar to the Bindango rock. Some portions seem to be

of volcanic tuff-breccia nature, but others are more definitely floodborne silts and rock fragments. Other parts again are a very rough-looking, ferruginous, uneven-grained sandstone, passing here into a pebbly bed, there into a silt bed, evidently formed under very changeable conditions. Only obscure fragments of carbonised wood have been obtained in these rocks.

The sandstones north of Amby and Mitchell at the head of Basalt Creek, Black Creek, Eastern Creek, &c., between Wahroonga and the Maranoa River, are not dissimilar to the sandstone described above. Tentatively, until wells and bores in the region give us fossil evidence, it is best to regard that belt as Desert Sandstone or Cretaceo-Tertiary in the main. It obscures the boundary between the Cretaceous and Walloon and most of the softer beds in the Upper Walloon, and throughout the area comprised between Amby and Mitchell on the south, and Kilmorey and Mount Kennedy on the north, we see great stretches of sandstone country the age of which we can only guess at, since it is impossible to say definitely in the absence of shales and fossils which bed it is. The part which we have marked UC has a typical Desert Sandstone vegetation consisting of lancewood (near Amby), yellow bloodwood, grevillea, sugar gum (rusty gum), pear, &c., but the boundaries shown on the map in this quadrant are only approximate.

Isolated patches of this Desert Sandstone also appear about ten miles north of Forest Vale.

Opal under the Basalts.

The entire country from Mitchell and Amby north to Kilmorey has been basalt-capped. The basalts now form scattered residual cones and plateaux. These basalts are of the same age as those of Mount Hutton, that is Middle Tertiary, and often they cover interesting Tertiary deposits.

It is safe to say that there were numerous foci of eruption and the flows did not all originate near Mount Hutton. Thus under a basalt capping which forms a hill about 800 yards south-west of Amby railway station there are tuffs underlying the lava at the western end, while the lava overlies sandrock at the northern and eastern sides. However, all the quartzite sandrock is not identical. While some represent Upper Cretaceous sandstone, other parts are recemented, silicified drift-sands with a common opal matrix, the basalt having filled a creek-bed. This type of quartzite is coarse-grained, often conglomeratic, and full of petrified opalised wood of strongly Tertiary character. A well sunk in the paddock north of the basalt hill is bottomed in drift-sand.

Another basalt hill about three miles north of Amby overlies a conglomeratic boulder bed consisting of smoother boulders of quartzite, chert, chertified breccia, opalised wood, &c. The

opalised wood is of two ages, the one sort being waterworn pieces possibly of Early Tertiary or older age, the other complete petrified logs and wood sections of Middle Tertiary age. In the silicified sandrock under the basalts, common opal is very common not only as wood opal but also as little pipes infilling hollows. The conglomerates are specially prone to opalisation.

On Selection 268, parish Barambaribal, opalisation under the basalt is very pronounced, and here a search for previous opal would be amply justified.

Faults.

Indications of one important fault have been met with. It has been dotted in on our maps, but otherwise has not been allowed to influence the modelling of the maps. The maps are based on field observations of soil, flora, and where possible rock outcrops. If we were to end-off our formations neatly against these supposed faults and show them definitely thrown back along the line of fault on the supposed downthrow side, the map would no doubt look better but would be artificial and not true to fact. The faults are not sufficiently definite to allow us to show them with precision.

The fault referred to is a north-south fault of which indications are seen in the change of country from Amby north along Amby Creek, Bottle-tree Creek through Kilmorey, along the eastern escarpment of the Dividing Range to Huttonvale. A study of the general geological map of Queensland shows that the break in structure along this line continues north almost to the mouth of the Burdekin through the basalt areas of the Buckland Tableland, Springsure, and Clermont. From the fact that all formations up to the Cretaceous have been displaced along the line, and from physiographic considerations, the age of this fault must be regarded as Late Cretaceous or Early Tertiary.

There are also somewhat indefinite field indications of another fault striking east-north-east from Kemp's Creek (Maranoa River) past Mount Kennedy on the north side and past Mount Hutton on the south side. The country south of this fault would have been downthrown.

In neither case is field evidence of so definite a nature as to allow one to pronounce these fault-lines as more than probable. They are later than the Cretaceous Marine and antecede the basalts.

(d) The Cretaceous Marine.

We have extended the demarcation of the boundary between the Cretaceous Marine and the Walloon from the point where Mr. Saint-Smith left off to the Maranoa River, as the map (Plan 1) shows. The lowest bed in the Marine Cretaceous is a

porous sandstone of very even grain size, rounded grains and varied hues on the surface with intercalated sandy shales of diversified colours. This contains obscure casts of mollusca in places. The topmost Walloon beds are a somewhat similar porous sandstone (Nullawurt horizon) with intercalated carbonaceous and shaly beds and obscure carbonised plant remains. The transition seems gradual. The whole of the porous sandstone was formerly regarded as Blythesdale Braystone. Immediately above these porous sandstones of the Cretaceous and outcropping about one and a-half miles south of Minka, there is a strong bed of ferruginous sandstone containing fossil wood and molluscan casts including Corimya, Fissilunula, and Glycimeris.

Physiographic features indicate a bend of the boundary line towards the railway line at Bungeworgorai Creek and then back again north-west to a point north of Mount Bindango on Dargal Creek. Cretaceous shales with copi (gypsum) were the country rock around Mount Bindango. Two miles east of Selection 28 on Taboonbay Creek, Cretaceous Marine fossils of the basal type were again met with. We obtained *Maccoyella reflecta*, Glycimeris, numerous minute gasteropods, and fish vertebra. Again, on portion 267, parish Baranbanbal, and at Washpool Dam on Amby Creek between Wahroonga and Taboonbay, cretaceous fossils were chiefly Corimya, Fissilunula, Glycimeris, and *Maccoyella reflecta*. The same horizon is met with on the Mitchell-Forest Vale road twelve miles north of Mitchell.

Where fossils are not met with, the occurrence of gypsum in the shales is a good indication of the rocks being of Cretaceous and not Walloon age.

On Mount Abundance Station, in the banks of Bungeworgoria Creek we obtained *Maccoyella corbiensis*, *Belemnites australis*, and a Turbo specimen. These belong to a higher horizon than the fossils got in the other localities mentioned.

Since the Cretaceous is mostly soil-covered plain and rock, and exposures seldom occur except where the formations are disturbed, it was considered advisable to endeavour to arrive at the general dip of the Cretaceous from the boring records of the Hydraulic Engineer's Department. Consequently an examination of sections of bores south of Roma and Mitchell was made. Since the boring records have been made by men insufficiently trained in geology they must be handled with caution, but certain deductions can be arrived at.

Comparing the Wallumbilla bore, started practically on the border line between the Walloon and the Cretaceous with the Roma bores, we find that the former passes through alternate grey shales and sandstones, reaching a pipeclay and sand-drift with a coal-seam at 860 ft. approximately 200 ft. above sea-level,

while the latter bores pass through blue shale to between 300 and 400 ft. and then go into alternating grey shales and sandstones with also brown shale and lignite about 700 ft., also roughly 200 ft. above sea-level. From field observations coupled with an examination of bore data we can deduce that a large thickness of blue shale (over 400 ft.) forms the base of the Cretaceous, and the uppermost Walloon strata consist of grey shales and sandstones with coaly bands, which cannot be correlated because their nature is lenticular. Pipeclays also frequently come in in this series, as do also sand-drifts.

The Mitchell bore we find passes into formations of Walloon character at 158 ft. and coal occurs at about 930, i.e. about 770 ft. below the top of the Walloon. The Morven town bore strikes the top of the Walloon about the same depth and finishes in palæozoic schist which comes in at 2,485 ft., which is interesting in connection with the alleged occurrence of granite at the head of the Warrego and the existence of serpentine at Eddystone Vale. Nive Downs has many bores which pass into Walloon rocks at 900 ft. to 1,000 ft. in depth. The average westerly dip between Forest Vale and Nive Downs must be exceedingly slight, amounting only to about 1,000 ft. in sixty miles, or say 20 ft. in a mile. The southerly dip is best studied south of Mitchell and Roma.

Commencing with the Bonus Downs bores about fifteen to twenty miles south-south-west of Mitchell, the Annie Vale and Oolandilla bore sections are strictly comparable, the latter lying about thirteen miles north and seven miles east of the first. The base of the Cretaceous is at approximately 1,000 ft. in the Annie Vale and 800 ft. in the Oolandilla bore. They yield a southerly dip of between 40 and 70 ft. to the mile.

Cypress Downs, roughly sixty miles south of Mitchell, has the base of the Cretaceous at a depth of 1,800 ft., giving an average dip of 30 ft. to the mile. It should be mentioned that the dip between the Annie Vale and Oolandilla bores is about 260 ft. in thirteen miles, or 20 ft. per mile. These facts point strongly to the dip getting less towards the south. The Cypress Downs bore, again, has coal at 2,404 ft. as against 930 ft. at Mitchell—that is, a dip of nearly 1,600 ft. in sixty miles—but though the coals belong to the same zone they cannot be strictly correlated. Foyle View about thirty-seven miles south of Mitchell has the Walloon about 1,465 ft., this being something like 35 ft. to the mile of a dip southwards. Woodlands, about the same distance south, shows the Walloon coming in at about the same depth, giving the same amount of dip.

The Weengallon bores about 100 miles south of Mitchell have the Walloon type of rocks showing at 2,000 ft. yielding a southerly dip of 1 in 20 ft. in the mile. The Bundilla bore, on longitude 144 deg. 29 min. and latitude 27 deg. 48 min. west of the Charleville-Cunnamulla line, has the Walloon rocks

commencing about 1,700 ft. On bore evidence it is also deduced that there are south of Roma and Mitchell rolls in the strata on north-south axes. Thus Roma seems to be slightly east of a gentle anticline passing through Bungeworgorai, Muckadilla on a synclinal axis, Mitchell again on another gentle anticline or roll, which has its axis slightly west of Amby. The Tullundunna bore, again, seems to indicate a syncline on Bonus Downs south of Mungallala.

Since the blue shale series seems to be fairly typical of the basal Cretaceous in all the bores, the above deductions are roughly correct.

The southerly dips north of Roma and Mitchell average roughly 60 ft. in the mile, hence the records just given show a gradual but gentle flattening of dip which, as will be seen later, is consistent with the increases in dip noticed in passing north from Injune Creek to the Carnarvon Range.

(E) The Walloon Strata.

To get a preliminary idea of these rocks at the outset of the work we made a traverse from Roma to Durham Downs and studied the strata at Durham Downs and along Eurombah Creek in rather more detail than the rest. The watershed between Eurombah Creek and Scott's Creek was found to consist of Bundamba rocks.

(i.) *Some Details of Country Traversed.*

A brief geological description of the country between Roma and Durham Downs is useful in leading up to a general description of the Walloon.

For a distance of five miles out of Roma following the Mount Hutton road we have soil-covered lightly forested plain with blacksoil belts and more sandy loam belts. The timbers are box (*E. populifolia*) and ironbark (*E. melanophloia*), small brigalow (*Acacia harpophylla*) belts, and scattered myall, &c. The grasses are very good, including much Mitchell grass, and the rich loams and black soils point to typical Cretaceous formation. Crossing the Bungil Creek we get a very much sandier type of country, and the rock is a white porous sandstone with shell casts. It is the horizon formerly called the Blythesdale and is the base of the Cretaceous. We followed up the Bungil on the eastern side and continued for ten miles through undulating country of a sandy loam nature derived from porous sandstones and interbedded shales, which, however, did not show in outcrop anywhere. Most of this was probably Upper Walloon. About twelve miles from Roma a great deal of gravel shows on the hills. This is probably derived from a conglomerate bed. About sixteen miles from Roma near Brown's dam, on Selection 70, parish Mooga, there is a small sandstone hill, a mesa with cliff scarps. The sandstone was seen to lie so

flat that only the merest trace of dip, in a south or south-east direction, could be seen. In a well near this hill coal is said to have been got at a depth of 60 ft. Proceeding towards Mooga, a heavy black soil with myall was observed on the camping reserve; this is evidently on a calcareous belt. North of this on the rise forming portion 53, parish of Mooga, there is a coarse gravel resting on calcareous soil. It seemed uncertain whether this was a wash or derived from a conglomerate, but further study elsewhere forced us to regard it as superficial. From this selection on to Mooga Creek crossing, at the foot of the Dividing Range, brigalow scrub country predominates. A few sandy belts occur. Conglomerate or boulder cappings are more abundant, and always on the hilltops, especially near the range. Obviously these occupy no stratigraphic position in the Walloon series. The brigalow scrub country represents shale outcrops; the interspersed forest belts represent interbedded sandstone. From Mooga crossing, about half a mile south of the Dividing Range, to Frankvale Creek, about four miles north of the range, open sandy country predominates with ironbark, box, ironwood, Moreton Bay ash, and other timbers which, grouped together, indicate a good yet sandy soil with rock fairly close to the surface. Belar scrub forms strong thickets in places; but belar is distinctively a sandy loam timber.

From Frankvale Creek to within five miles of Durham Downs head station we have brigalow and belar scrubs. Some belts are solely brigalow country, with very heavy clay-shale soil; other belts are more sandy belar-wilga-sandalwood country, representing sandstone belts. Yet both the shales and the sandstones are exceedingly rich in lime.

About five miles from Durham Downs on the Roma road commences a group of calcareous sandstones which yields a heavy loamy soil. This country is predominantly open box country, but is characterised by having scattered through it clumps of brigalow.

Coal-seams occur in the calcareous sandstones at Durham Creek. One seam exposed in Durham Creek one mile north of the station measured 12 in. in thickness. It was an inferior coal. It is overlain by 5 or 6 ft. of felspathic sandstone over which rests a 2-ft. bed of ironstone, and it is underlain by shaly sandstone.

The outcrop of this seam is hidden by brigalow scrub. The dip is south-west at a very low angle. In Eurombah Creek above the junction with Durham Creek we find high banks carved in felspathic sandstone. The dip appears to be south-east at very low angles. About opposite to the junction of Eurombah Creek and Bluff Creek we see conglomerates underlying the felspathic sandstones. They are not very coarse, the pebbles in them being only the size of billiard balls. Further up Bluff Creek the sandstones become more and more silicious.

The country between Eurombah Creek and Scott's Creek consists almost wholly of silicious sandstone.

The conglomerate referred to above we take to be the conglomerate overlying the Bundamba Series. The Durham Downs coal lies in felspathic sandstone near the base of the Walloon, and corresponds in position and in its appearance and composition to the coal at Proctor's at the head of Hutton Creek, which will be referred to later. It is a shaly, dirty-looking coal. The Durham Downs head station and the box flat with clump brigalow country which forms most of the station are on very calcareous formation, partly calcareous sandstone and partly limestone. A hill charted as "Lighthouse Hill" consisted principally of spheroidally weathering limestones and calcareous shale. These rocks outcrop over a width of four or five miles and correspond with the Injune Creek calcareous series. Myall Downs is also on this belt.

The following fossils were found on the Durham Downs journey:—

(*a*) At Shanahan's dam—*Cladophlebis australis.* Tæniopteris sp., *Tæniopteris spathulata,* and petrified wood (Araucarites).

(*b*) At Frankvale Creek—Petrified wood; sandstone containing a porous structure in silica left after the weathering of a portion of the petrified wood and innumerable stems of Equisetales and *Araucaria polycarpa* in concretions.

(*c*) At Eurombah Creek—Dictyophyllum sp., Tæniopteris, *Cladophlebis australis,* Sphenopteris sp.

(*d*) On Durham Downs—Equisetum, Equisetales, *Tæniopteris spathulata,* Pterophyllum, and other obscure impressions in ferruginous shales.

(*e*) On Lighthouse Hill—*Tæniopteris spathulata,* Pterophyllum, Araucarites, &c.

Since the above was written an important fossil discovery has been made at Durham Downs. A skeleton identified by Mr. H. Longman, Curator of the Queensland Museum, as that of a dinosaurus has been discovered in the Walloon Series near Durham Downs Head Station. This is the first record of Jurassic dinosaurs in Australia.

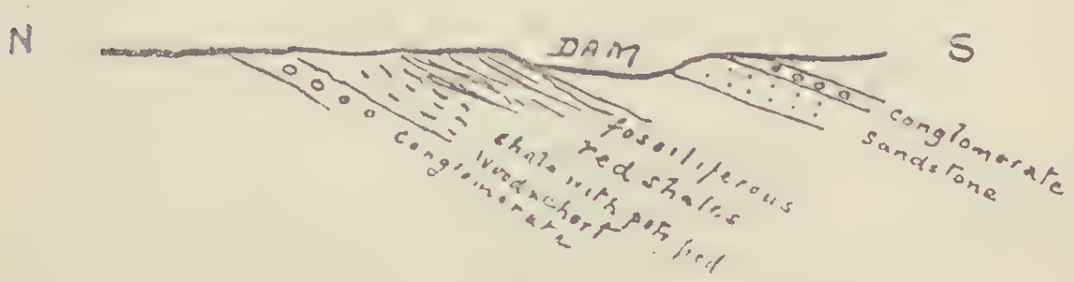
Petrified Wood.—A petrified log 30 yds. long was seen on Lighthouse Hill (Durham Downs), in the calcareous mudstone series. It was 2½ ft. in diameter. It is characteristic that in the calcareous mudstones petrified wood is turned into ironstone, which is the case with this log; while in the silicious and felspathic sandstones the fossil wood is silicified.

A notable petrified wood belt is crossed between seventeen and twenty-two miles from Roma on the Durham Downs road.

It might be called the Solitary Creek belt. At Shanahan's house there are sections of fossil logs 2 ft. in diameter bestrewn over the surface. Some of the pieces are 10 to 12 ft. long. The wood in this belt is silicified, and contains splashes of coloured wood opal. This belt we take to be identical with the fossil wood horizon which occurs from Horseshoe Lagoon to Orallo, where fossil wood (including fair-sized logs) is fairly abundant. Wherever we obtained fossil wood in calcareous strata we also obtained ironstone concretions which when broken contained casts of oval scaly seed-cones which strongly suggested the cones of Araucarian pine.

From the fossils it is obvious that the whole series from Eurombah Creek to the vicinity of Roma is Walloon; the strata outcrop in the same order as on the Injune Creek road. The sandstones between Mooga and the Frankvale Creek are undoubtedly the same belt that we meet crossing the Dividing Range to Injune Creek. The coals of Frankvale Creek (Corinda Station) which were not visited are, however, from the description which we heard of them, probably identical with the Injune coals; those of Lower Durham Creek are identical in position with the coals at Proctor's at the head of Hutton Creek; the coals reported from the Roma side of the Dividing Range near Brown's dam are in the same belt as the Cornwall coal, though there are so many seams in the Cornwall-Alcurah coal series that it is not clear whether we have the top or the bottom of the series here. The country on the Durham road is so soil-covered that outcrops are too infrequent to be of any assistance.

At Shanahan's an outcrop gave the following section, with a dip to the south at 15 deg.:—



The conglomerate beds are thin and composed of small pebbles. The indurated shale with petrified wood seems altered by hot-spring action. The red shales contain Cladophlebis. This is, however, of no stratigraphical value except to indicate that at this point the strata take a lurch, the dip locally steepening, while on Selection 70, Mooga, at Brown's dam, they are horizontal. The section also shows that in parts of the Walloon areas pebbly conglomerates come in at intervals. It is obvious that these are not continuous through the whole Walloon basin, but they are local. They are, however, important in the oil geology of the region.

The following is a section from Selection 70 to that part of Mount Bassett which was ascended (Fig. 6) :—

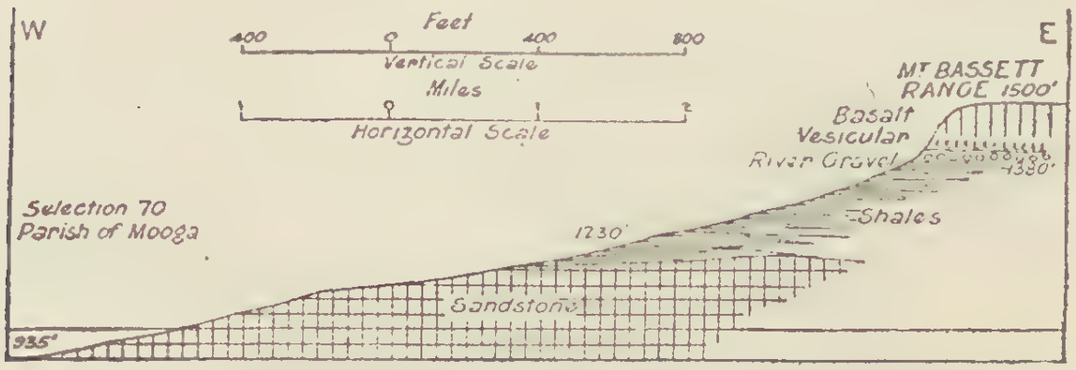


Fig. 6.—E.W. Section from Selection 70, parish of Mooga, to Mount Bassett Range.

Dips on the Durham Downs Journey.—It is only in isolated places that dips are at all observable, and it must be recollected that it is only where dips are fairly steep that creek erosion in such flat country has a tendency to expose a section. The dips actually observed are therefore in most cases extraordinary dips. At Shanahan's we got a southerly dip at 15 deg. On Selection 70, parish Woonga, the strata lay almost horizontal. On the Dividing Range hardly any dip was noticed. At Frankvale Creek on the Durham road, a west-south-west dip at 7 deg. was noticed, and current dip on west-south-west at 21 deg.

On Durham Downs between the head station and Lighthouse Hill we got a west-north-west dip at 5 deg. about a mile east of the station, but a little further eastwards the strata lay flat, and still further east we got north-east dips instead of westerly ones. At the coal outcrop in Durham Creek there was hardly any dip, and along Eurombah Creek very gently south-west dips predominated. Indeed the general conclusion arrived at is that the calcareous strata which runs through Durham Downs treated as one series lie practically flat, but through chemical change, expansion on hydration, or such alteration they have been puckered into small domes. It will be noticed later that this is also the case with the Injune Creek series. This folding does not affect the interbedded sandstones. Similar local folding is very common on the Oakey Coalfield, Darling Downs.

Along Eurombah Creek south-west dips at very low angles predominated. The sandstones between Eurombah Creek and Scott's Creek also lay very flat, or dipped very slightly to the south-west. The hills ascended in this locality rose over 200 ft. higher than the Durham Downs country some miles to the south. However a dip of only 100 ft. in the mile would bring these sandstones well underneath the coal-bearing strata of Durham Downs.

Conglomerates.—No conglomerate beds are shown in the Roma bore section, yet in the traverse to Durham Downs we met with conglomerates truly interbedded in the following places:—

(*a*) At Eurombah Creek between sandstone beds. These conglomerates are regarded as the base of the Walloon.

(*b*) Small conglomerate seam in sandstone at Frankvale Creek.

(*c*) Two small conglomerate seams at Shanahan's (analogous to similar beds in the Orallo belt).

In each case abundant fossil wood was found immediately under or over the conglomerate. The petrified wood horizon at Eurombah Creek lay immediately under, at Shanahan's immediately over, the conglomerate. At Shanahan's the petrified wood bed passed upwards into a red bed with Cladophlebis and other leaf remains. It is possible that each of these conglomerates is equivalent to a disconformity, or a period when land conditions intervened over considerable portions of the Walloon subsidence area. The red bed referred to above also points to a temporary dry land patch or a swampy shoal, in the midst of the Walloon basin. The red bed picked up near the junction of Bungeworgorai Creek and Aleurah Creek under a boulder mound contains the same fossils and has similar characters. It is probably the same, and if so the Aleurah Cornwall coals lie immediately south of Shanahan's, their outcrops obscured by brigalow scrubs and soil.

Though fossiliferous red ironstone bands are sometimes regarded as an indication of Walloon strata, we advise caution in using them as such, having found the same kind of beds in the calcareous members of the Ipswich Series. Likewise, cone-in-cone limestone, which is common in joints and faults in the Walloon, also occurs in the Ipswich.

Now we will likewise traverse the features of the section between Roma and the Bundamba boundary along the Injune Creek to Westgrove road.

From Roma north-west by road to within two miles of Minka railway siding, undobuted Cretaceous formation underlies the blacksoil plain. About two miles south of Minka the horizon with fossil-wood associated with Cretaceous shells is crossed. Nearer Minka the country gets more and more sandy, and a mile beyond Minka at Gum Creek fine-grained sandstones of various kinds are interbedded with sandy shales of a reddish and yellowish colour. In the sandstones were casts of a mollusc shaped like a Maccoyella. This country is much overgrown with low prickly-pear. This is the horizon formerly known as the Blythesdale Braystone. The sand-grains are remarkably rounded, making the sandstone very friable.

At Nullawurt railway siding hills are seen composed of white to grey fine-grained sandstone with no signs of fossils. The formation dips south-west or south at very low angles. A mile or so further on shales are seen interbedded with a similar sandstone. They are carbonaceous clay shales. The dip is here south-west at 6 deg. The formation is undoubtedly now Upper Walloon. Passing the Yingerbay railway station hills of porous grey sandstone with Equisetite stem impressions on cleavage planes are seen. They dip south at about 6 deg. A band or ironstone of concretionary nature occurs on a cleavage plane.

At Taylor's wheat farm, about eighteen miles from Roma, a deep heavy sand occurs. This sand belt is equivalent to the sandy patches seven to ten miles north of Roma on the Durham Downs road.

North of this brigalow country, rather undulating and bestrewn with Tertiary river-wash in places follows. The river-wash is waterworn and stream-sorted.

Near the point where the Orallo road crosses the Bungeworgorai, opposite 59v, parish of Bungeworgorai, the creek has cut deep into the soft Walloon formations, giving frequent precipitous banks. One of these gave the following section, from above down:—

	Ft.
(1) Surface soil .. .. }	10
(2) Clay .. .. }	
(3) Sandstone	12
(4) Grit	6
(5) Conglomerate with boulders up to 2 ft. in diameter	6
(6) Shales (clay shales)	6

The whole series dip south at 6 deg. This section is interesting because of the conglomerate. From this point to Orallo the country becomes more and more sandy, consisting of sandstone country capped here and there with Tertiary river-gravel. Two miles south of Orallo fossil wood in large and thick lengths becomes very abundant. The wood here is probably equivalent to that on Solitary Creek, and the belt about four miles wide in a north-south direction.

No coal was seen on the road between Roma and Orallo, but it was learnt from various reliable sources that a coal-seam outcrops near the Bungeworgorai Creek on 59v, parish Bungeworgorai, and another was seen from the train in a wash-out on portion 2v, parish of Bengalla. The latter appeared only 6 or 9 in. thick, but the former is 3 ft. thick with a few thin shale-bands in it. It was opened up many years ago by means

of a tunnel but found unprofitable, both on account of the bands and the poor quality (Cameron, Q.G.M.J., 15th October, 1913).

From Orallo along the railway line to Injune Creek the following formations occur:—

Orallo to 32 m.—Sandy loam to heavy black soil representing alternating sandstones and shales with patches of Tertiary river or creek waste on the hills.

32 m. to 33½ m.—Sandy country overlying sandstone.

33½ m. to 34½ m.—Sandstone.

34½ m. to 35¾ m.—Sandstone.

36 m.—Calcareous sandstone and shale.

37½ m.—Sandstone.

38 m. to 38½ m.—Belar-box-sandalwood country, indicating calcareous shale.

38½ m. to 39½ m.—Alternating shales and sandstones.

40 m. to 40½ m.—Clayey soils indicating shales.

41 m.—Clay soils indicating shales; shales seen outcropping, dip south-west, at between 2 and 3 deg., southerly factor of dip about 1 in 50.

42 m.—Silicious sandstones.

43 m.—Heavy sandy loam, belar scrub, overlying probably felspathic sandstone.

44 m.—Calcareous clay soil, overlying probably shales.

45 m. to 46 m.—Calcareous shale with Cladophlebis impressions.

46 m. to 47 m.—Alternating sandstones and shales with ferruginous bands containing fossil remains chiefly Cladophlebis.

47 m. to 51 m.—Sandstone of felspathic nature and somewhat calcareous, showing steady and constant dip to south on 1 in 45 to 1 in 50. A ferruginous shale band occurs at 49¾ miles, containing Cladophlebis, Tæniopteris, Equisetites, &c.

From the 51-mile to the 61-mile alternating sandstones and shales occur, almost all of a very calcareous nature, yielding calcareous loamy soils. At Injune Creek we get a number of little treeless plains with heavy black soil. They seem to form a definite horizon striking north-north-west over the Mount Hutton estate. These little plains occur also on portion 3, parish of Crowman, a fact which links up the parish of Crowman coals with the Injune coals.

North of Injune railway station the country becomes more and more sandy, derived from felspathic sandstone. About ten miles north of Injune Creek station we pass on to silicious sandstone country of typical Bundamba appearance.

In the direct north-south traverse one does not see any coal outcrops. They are hidden under black soils either in brigalow scrubs or little treeless plains. It is in the examination of the creek-beds east and west of the line of section, especially where the creeks have cut ravines, that one gets an idea of the coal-seams.

Before proceeding to discuss the traverses made other than the direct north-south section, it is desirable to mention that the dips in the country between the 51-mile and 61-mile show that the calcareous beds of this zone lie on the whole very flat, but are, as at Durham Downs, folded into innumerable small domes and troughs due to the hydration and expansion.

The felspathic sandstones north of Injune belong to the Walloon Series and form in fact the basal beds. A conglomerate separates this series from the more silicious Bundamba sandstones. There is also a defined conglomerate bed in the middle of the Basal Walloon Series, north of Injune, and minor ones as in Cook's well near Injune.

Parish Springbok and Byan Byan.—Some time was spent in examining this quarter of the Mount Hutton estate. Running west by road from the 51-mile (Injune line) we passed over calcareous sandstones, with some silicified wood dipping south-west at low angles, for seven miles, and then enter brigalow scrub overlying calcareous shales. About eight miles out we pass Jennings's (Bore 3A) water bore, which at the time of visit was down about 400 ft. Chapman's bore, about twenty chains further west, was sunk to 500 ft. without getting more than a trickle of water. Jennings's bore had not struck water in any useful quantity at the time of inspection. Both these bores have, however, yielded inflammable gas, which, from its lightness and the colour of its flame, seems principally methane. A sample of this gas subsequently analysed proved to be methane. The country passed through in Jennings's bore was principally shales with some sandstone. At 160 ft. a very hard stratum described by the driller as "grey granite" was passed through; in reality this was a hard cherty limestone. This continued to 195 ft. At 209 ft. a "brown oily shale" was passed through. *At 200 ft. one foot of coal* was passed through, then more brown and black shale to 264 ft., where a "hard streak" was encountered. Another hard streak was recorded at 282 ft. Then "oily brown shales" were passed through from 292 to 298 ft., then more "grey granite" (chertified limestone) to 305 ft. Then from 305 to 324 ft. cement stone (hard limestone), then more oily shale 324 to 330 ft., then blue shale and gas, then brown shale and then at *349 ft. two feet of coal.* More "hard streaks" were got below this. The entire section showed a quick alternation between sandstone, shale, calcareous beds, carbonaceous beds, and "hard streaks," which is a condition favourable for oil formation.

For a distance of seven or eight miles west of Jennings's bore brigalow-belar country overlying shales predominated. No dips were obtainable. About sixteen miles from the railway line the brigalow country ends at a small gully which runs north-east and much more sandy sandstone country takes up. This has a low south-east dip. The sandstones are mainly felspathic sandstones. On Selection 30, parish Springbok, a dip of 18 deg. to the east was obtained. Other dips to the east and north-east were observed west and north-west of this. The sandstones have the character of those of the base of the Walloon (*see* figs. 2 and 4). West of the parish of Springbok the Dividing Range is flanked on the eastern side with silicious sandstone escarpments, and capped by basalt in places as shown on our maps. The very linear alignment of the scarps suggests a fault-line, but no positive evidence of faulting is available. The country east of the scarps is thickly covered with rock waste. The sandstone of this range (Mount Byan Byan) is silicious and has the physical characters of typical Bundamba formation, which, however, it is not. The dip changes abruptly on coming to the range. The dip on and in the range is south-west at about 3 to 5 deg. The height of the range is about 2,450 ft., or 700 ft. higher than the east-west portion of the Dividing Range lying south-east of Mount Byan Byan. Everything points to the Byan Byan range being a sharp fold which has been *faulted* with the western limb downthrown, bringing the Middle Walloon up against the Basal Walloon. (Fig. 4.)

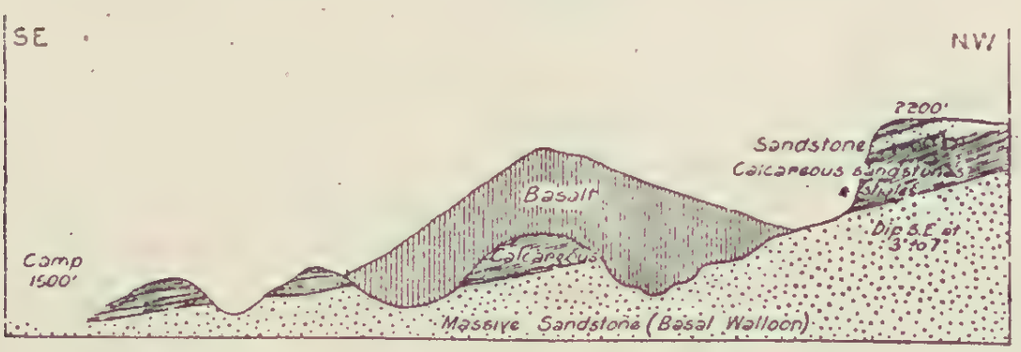


FIG. 7.—North-south Section from south corner of portion 43, parish of Crowman, to precipitous spur from range.

Basalts have flowed from Mount Hutton over portions of this range, filling in valleys running south-west. The basalt flows probably preceded faulting, this being the only logical way to account for basalts east of the range being found resting on a level as low as 1,400 ft., while on the range and west of it they occupy levels of 2,000 ft. and over. (*See* fig. 7.)

Oakey Creek and Mount Hutton.—Along Oakey Creek we get calcareous Walloon strata of the same type as those of Injune Creek. About three miles south of Mount Hutton we get a boulder area seemingly akin to the glacial heaps found in many

places, underlying basalt at a level of about 1,400 ft. This points to the glacial period being prebasaltic, especially as the boulders contain no basalt detritus.

In ascending Mount Hutton itself we encountered sandstones *in situ* at various levels. Thus at the Lakes, 2,360 ft., there is quartzite capped with basalt (*see* section, fig. 2), and again at 2,540 ft. we get sandstone. The Lakes have no resemblance to crater lakes, and are simply small hollows which have formed through a subterranean leakage of flood waters through tuffs and this leakage getting choked up again.

It is obvious that the basalt flowed over a very uneven surface. The sandstones encountered on Mount Hutton were of the silicious type.

Hutton Head Station.—Travelling from Injune Creek railway station east to the old Mount Hutton homestead we pass through brigalow-belar scrubs for ten miles or so, which cover the calcareous rocks of the Injune Creek, Myall Downs, and Durham type. Within four miles of the station we enter some hilly country composed of massive sandstone, some silicious, some felspathic, with ironbark pine forest. These sandstones dip gently south-west in under the calcareous series.

In the bed of Highland Plains Creek, and in that of Injune Creek near the homestead, the sandstones were more silicious and noticed to dip steadily south-west on about 7 deg. At the Injune Creek crossing about two miles west of the homestead a conglomerate occurs which is probably the basal conglomerate of the Walloon.

Head of Hutton Creek.—On our return from Moolayamber we made for the head of Hutton Creek to inspect the coal there. The base of the Walloon was struck about Hutton Creek, near the boundary between Harding's Timor paddock and No. 6, parish Huttonvale (Johnson's Glentulloch paddock). The sandstones of the base of the Walloon were lying almost flat.

A well on M. E. Wilkinson's land, No. 3, parish Crowman, passed through a 4-ft. coal-seam at no great depth in sandstone and shale country. The coal was rather poor in quality, judging by the sample on the surface.

On Proctor's Selection No. 5, parish Crowman, an interesting coal outcrop occurs in felspathic sandstone formation. The exposure in the bed of the creek is 12 ft. thick and the base is underfoot. This seam is traversed by shale bands in places. In a well about 40 ft. east of this outcrop, wash was obtained to 20 ft., then coal to 24 ft. The well is on the creek bank. The coal dipped south-east at 45 deg. in this well. The sandstone over the coal in the creek-bank shows a gentle dip south-east at 4 deg. The coal-seam in the well is probably the same seam as in the

bank, brought down by a fold in the strata, brought about by adjacent volcanic intrusions, and the top of the seam has been eroded away. (*Vide* fig. 10, p. 74.)

W. Weir stated that he got 14 ft. of coal in his well on the adjoining selection, portion 4, parish Crowman. This seam is probably a lower seam than the one occurring in Wilkinson's well. It appears to be the thickest seam in the Walloon and one of the dirtiest. Probably it is also very variable in thickness and quality.

Opal matrix is found in the basalt at Maintop, and also in the basaltic hills about Kilmorey.

The Walloon Series North of Amby and Mitchell.—In the left bank of Maranoa River, opposite Moore's house, portion 5, parish of Havelock, a very interesting 6-in.-thick bed of fossiliferous shale was met with containing *Tæniopteris spathulata, Cladophlebis australis,* and Sphenopteris sp., together with innumerable chitinous films up to ¼ in. in diameter but so thin as to be quite translucent. These films curl up on desiccation, burn with an organic odour, and are reddish brown in colour. The other fossils are represented by black carbonised impressions. The films were at first believed to be insect carapaces akin to cockroach shells, but, although pitted in the same manner as insect elytra, a microscopic examination failed to furnish any definite proof of the animal origin of these shells. It is quite possible that they may be spore or seed covers. Yet it is strange that these should be preserved in chitin while the other plant remains are carbonised. The shale in question is thinly laminated. Felspathic sandstone overlies and underlies the shale.

At Donnybrook, a few miles north of Moore's, it is stated that a 4-ft. coal-seam was recorded from a well. North of this, at various points in the Maranoa River, small coal-seams occur in the banks in interbedded shales and sandstones. The Forest Vale coals occur in very similar rocks to the Cornwall coals. The fossils in the shaly beds are largely Sphenopteris, Ptilophyllum, Cladophlebis, and Tæniopteris, like those of the Orallo measures. The clays near the coals are, as at Aleurah, often stiff pipeclays from aluminous shales and the coals are sulphurous. Only small seams were noticed, and the country rocks are very rapidly disintegrated on exposure.

As already pointed out, a long stretch of country lying between Mitchell and Kilmorey is with few interruptions covered with silicious sandstone which is largely of Desert Sandstone age. Probably a great proportion of the sandstone met with in this area is Upper and Middle Walloon; for in many places, as at Taboonbay Creek, Wahroonga, the spinifex stretch fourteen miles north of Mitchell, or other places, much of the sandstone is closely akin to the Nullawurt sandstone north-west of Roma (Blythedale Braystone); and in other places as at Kilmorey, Mount Kennedy,

&c., the sandstones resemble those of Flagstone Creek near Cornwall, or those of the big sandstone series of the Dividing Range north of Roma. It is, however, impossible at present to distinguish between them on lithological grounds; there are no fossils in them determinable at least up to the present, and bores have not been sunk in sufficient number to give any idea of rock sequence.

However, at Moore's, portion 5, parish of Havelock, the strata in the Maranoa River are typically Upper Walloon. At Donnybrook we are still in the Upper Walloon. On Forest Vale Station we are in the Middle Walloon (Orallo-Cornwall series). North-east of Forest Vale and north of Mount Kennedy and Kilmorey we have a wide expanse of blacksoil country, highly calcareous, with brigalow-belar scrubs extending over Toolumbilla and Womblebank. This is so closely akin to the Injune Creek belt north of Roma and to the Durham Downs country that one can unhesitatingly pronounce it Lower Walloon. The fossils in this calcareous belt are *Tæniopteris spathulata, Cladophlebis australis,* and *Otozamites Feistmanteli.* These are plentiful. Other specimens are probably present, but not recognisable in the ferruginous bands interlaminated with the calcareous beds. In a well about five miles east of Forest Vale a fine specimen of Sphenopteris (sp. undescribed) was obtained by Mr. Lethbridge, who kindly gave us a piece for the Museum. This well, however is sunk in what appears to be the big sandstone between the Orallo series (Middle Walloon) and the Lower Walloon.

Sphenopteris with Tæniopteris and Cladophlebis are very abundant in the interbedded shales on the Maranoa River from Forest Vale to Mitchell Downs. Sphenopteris series typically Middle Walloon.

Petrified wood is, we are informed, extremely abundant on Maxwell Creek north-west of Forest Vale. Apparently this is the same horizon which we have on top of the Middle Walloon coals at Orallo.

The Lower or Calcareous Walloon, which forms a very wide belt between Toolumbilla and Womblebank, narrows enormously towards the west. Where this belt was crossed north of Forest Vale on the road to Eddystone Vale it is only three miles wide at most. However, as the dip is 7 deg. where observed, there is room for several thousand feet of thickness of strata in this short distance. However, north of the Calcareous Walloon country on the Maranoa River there were Desert Sandstones which may cover Calcareous Walloon in part. There is also a possibility of the calcareous series passing by gradations into a sandstone towards the west, owing to the sediments of that period having a different composition in this locality.

The red ironstone bands in the Calcareous Walloon of Toolumbilla are the main repositories of plant fossils, but the fossils are not confined to cleavage planes; in fact the rock has no

cleavage, but the plant remains lie in all directions and one is as likely to get a good fossil by breaking the rock in one direction as another. The common alteration of wood to limonite in these strata and the metamorphosis of other plant remains to ferruginous material suggests that these red beds are replaced peats. On that assumption it is easily understood why the fossils are not oriented in any definite direction.

The dips showing in the Walloon areas north of Amby and Mitchell are mostly trivial, and in the country west of Kilmorey and north of Wahroonga they vary much in direction and are generally speaking unsatisfactory. However, taking the aggregate of the dips observed in the Cretaceous Walloon and Bundamba systems north of Amby and Mitchell, they are not inconsistent with the map prepared by us largely on lithological and physiographic data, as must be the case where rock outcrops are few and far between.

It is here apropos to enumerate the dips met with in this quadrant (Maranoa). At Taboonbay Creek near the old hotel site the passage beds between the Cretaceous and Walloon dip south-east at 2 deg. Exposures are rare because the climate of this entire region seems to have undergone desiccation leading to the filling up with recent detritus of all the gullies that once were carved in the sandstone. The creeks are mere remnants of what they once were in a previous wet cycle (*see* diagrams). About two miles north of Wahroonga Station there are sandstones dipping south at 10 deg., and current bedding to the north-east at 30 deg.

About six to seven miles north of Wahroonga a south-east dip at 10 deg. was noticed.

On Long Gully (branch of Amby Creek) the bulk of the sandstones lay very flat and none of the dips observed were reliable.

At Mount Kennedy the dip is south-westerly at low angles. On Toolumbilla the dips are mostly south-west. Four miles south-east of the head station they were south-west at 7 deg. The western portions of Toolumbilla show westerly and west-north-west dips, which on Forest Vale become north-west at a fair angle (7 to 10 deg.).

The Desert Sandstone areas south-west of Wahroonga hardly show any dip at all. On the Maranoa at Moore's house a slight easterly dip appeared but is not quite reliable, but on Kemp Creek further north we have north-west dips at low angles, but strong current bedding to the south-east at from 15 to 20 deg. At Forest Vale the dip appears from well records to be north-west, though in the Maranoa River at Jerry's Crossing a dip to the east at a low angle appears for some distance. Erratic dips were observed in the Desert Sandstone

hills on the Maranoa eight to twelve miles north of Forest Vale and, all at low angles, though in the Calcareous Walloon belt north of Jerry's Crossing the dip was west at 8 deg.

A sandstone horizon with interbedded ferruginous conglomerates occurs at the junction of Simpson Creek with the Maranoa River. The dip is erratic from north-west to south-west at low angles, with strong current bedding to the south. This sandstone is without doubt Desert Sandstone. The cement of the conglomerate is pisolitic. In proceeding thence to Eddystone Vale the sandstones soon take on the typical Bundamba character, and, by following the same bed up from Simpson's Creek camping reserve to the divide to the Maranoa, a steady dip of 60 ft. to the mile to the south and 60 ft. to the mile to the west was noted. This is fairly consistent throughout Crystalbrook, though near the south boundary at the junction of Bundara Creek and the Merivale River a dip to the east by north at 10 deg. was noted, and on Silverleaf Station the dip becomes south at 5 deg., changing to south-west at 7 deg. north of Toolumbilla.

The traverses so far detailed were made in the year 1920.

(ii.) *Divisions of the Walloon.*

The work done makes it convenient to divide the Walloon in the Roma area into the divisions or stages shown on the map and section. The subdivision has been made mainly on physiographic characters.

The Upper Walloon consists of fine-grained porous silicious sandstones, composed of waterworn, even-sized, rounded grains, and interbedded shales which are often carbonaceous. This stage contains several coal-seams, the Yingerbay coals, and has a thickness of 400 or 500 ft. and is met with in the Roma bore at a depth of 500 ft. It is indeed doubtful whether the coals on 59v and in that vicinity should be regarded as Upper Walloon or not. A conglomerate as already mentioned overlies those coals, and pebbles came in above the coals in one of the Roma bores. Below that conglomerate the sandstones are felspathic. Yet to make this the dividing line would restrict the Upper Walloon to 200 ft.

The Middle Walloon consists of an upper felspathic sandstone and intercalated shales of brown and grey hues, rich in plant remains on the cleavage planes. The lower portion of this horizon is very rich in silicified wood. Below these strata, which have a thickness of roughly 500 ft. and yield the first big water supplies, we get the Orallo coal measures, about 700 ft. in thickness, containing probably a score or more of seams of which eight or nine have been actually obtained in surface outcrop. The assorted rocks are calcareous sandstone, very felspathic, and aluminous shales which form pipeclays on exposure. Below the coal measures we get a shale series about

200 ft. thick, in part very hard brown, in part white porcelaneous hard clay shales. Underlying this there is a sandstone horizon, "the Big Sandstone," 400 ft. thick, consisting partly of calcareous felspathic sandstones and partly of calcareous silicious sandstones, fine-grained and quickly disintegrated by weathering. The total thickness of these strata is about 1,800 ft.

The Lower or Calcareous Walloon is a calcareous series consisting of alternating sandstones and shales, mudstones, and limestones with intercalated coaly and carbonaceous bands. It is impossible to say how many coal-seams there are in the stage, as it is quite impossible to correlate the seams occurring in the different bores. The ground is better standing ground than in the Orallo measures, and the water would not be as heavy. The total thickness of the stage is about 1,400 ft.

The Basal Walloon consists of sandstones, more or less felspathic, with ferruginous bands and becoming more silicious towards the base of the formation. Some shales are intercalated and at least one coal-seam near the top. The formation rests on a conglomerate which is arbitrarily taken as the transition to the Bundamba Series. The thickness of the Walloon runs into between 4,500 and 5,000 ft.

(iii.) *Features of the Walloon.*

(*a*) *Current Bedding.*—A most common feature in all the Walloon Series is current bedding. Usually the dip of the current bedding planes is in the same direction as the true dip but much steeper, but this is not by any means universal. Current bedding is commonest in sandstones, and has been noticed equally in the Upper, Middle, Lower and Basal Walloons.

(*b*) *Lenticularity.*—Another feature of the Walloon beds is the tendency of beds to thin out, thicken, and to include lenses of various dimensions of other rocks. Thus a lens of sandstone is sometimes imbedded in clay shale or *vice versâ*. Small conglomerates come in in places but have no great continuity. Coal-seams thicken and thin out very rapidly, especially in the Middle Walloon, and frequently bands occur in one place when a short distance away the seam is free from bands. This tendency to lenticularity is not as strong in the calcareous series of the Lower Walloon as in the Middle and Upper beds.

(*c*) *Ironstone Bands.*—Throughout the Walloon Series we meet with numerous small, ferruginous sandstone and ferruginous shale-bands up to 9 to 12 in. in thickness, sometimes prolific in fossils, especially Equisetite stems, but more often so concretionary that fossils are not to be got in them. The most concretionary ironstones usually have some relation to coal-beds, each lying 3 to 4 ft. above a coal-bed, and when such ironstones occur in Calcareous Walloon sandstone or shale the ironstone is often jaspery. Some of the supposed boulder beds met with in sinking sub-artesian bores are probably only concretionary

ironstone of a jaspery nature. No boulder beds occurred in the diamond-drill bores in the Calcareous Walloon.

A common alteration of fossil wood in the Calcareous Series is into hematite and limonite. As already stated, a fossil tree 120 ft. long converted into ironstone can be seen on Lighthouse Hill, Durham Downs.

Another form of ironstone which occurs commonly in the calcareous beds of the Lower Walloon and occasionally as at Aleurah Creek in the Middle Walloon, but always in rocks of a calcareous nature, is a red fossiliferous limonite which breaks with an uneven fracture and is highly prolific in fossil remains lying in all directions. There are no bedding planes in it, and the remains of Tæniopteris, Cladophlebis, Sphenopteris, and Otozamites lie at all angles and show on every face and fracture without any show of relation to a definite plane of deposition. These beds are in my opinion, without doubt, indication of temporary land conditions in the Walloon period, when ferns grew thick and formed a peat which was later replaced by oxide of iron, as commonly occurs with peats near ferruginous springs at the present day, or which may first have been replaced by carbonate of lime and later by iron.

It has been suggested to utilise the red beds as horizons in the Walloon. I am, however, satisfied that they cannot be so used, since they have no great areal extent, being lenticular like the other Walloon beds. Nor are they even confind to the Walloon. The Bundamba formation includes near its centre a shale horizon containing red beds, and there are similar red beds with Thinnfeldia in the Upper Ipswich at Spring Creek and Bullaroo Creek (branch of the Moolayamber) north of Boxvale. I understand that Mr. Reid has also found a red bed in his Marburg sandstone, belonging to the Bundamba Series.

The divisions of the Walloon are quite arbitrary, and can only be based on general lithological characters and the stratigraphical relation of the beds to known coal-seams.

(*d*) *Conglomerates in the Walloons.*—The section of No. 2 Roma bore contains a conglomerate at about 680 ft. which has also been found in places in outcrop in the Upper Walloon. In many places in the Middle Walloon near Shanahan's (Carl Marx Station), near Orallo (in Bungeworgorai Creek), and in various places on the Bungil small conglomerate beds have been noticed, but they are lenticular and have no stratigraphical value. They serve, however, as a testimonial to the near-shore or estuarine condition of sedimentation. No conglomerates have been seen in the Lower Walloon, and the boulder beds of the sub-artesian bores I am inclined to regard as concretionary.

In the Basal Walloon there are several large conglomerate beds—one in the middle of the series, another at the base, and

many no doubt lenticular beds in other places, like one met with in a well one mile west of Injune Creek station. The basal conglomerate of the Walloon has been picked up in many widely removed places and seems a fairly constant feature.

(*e*) *Yellow Beds in the Walloon.*—A character of the Basal Walloon sandstones which distinguishes them at once from the Bundamba sandstones is the yellow colour of the soil and the rock exposures, due no doubt to a lime felspar in the rock.

Still more strikingly yellow are the mudbanks in the creeks traversing the Lower Walloon calcareous sandstones and shales, and some of the calcareous shales of the Middle Walloon. The colour is suggestive of sulphur, but so far no free sulphur has been recognised.

From the stratigraphical point of view these yellow banks are, however, of great value, since they are constant in the Lower or Calcareous Walloon throughout South Queensland. Thus we have them in the Beaudesert, Boonah, Juandah, Taroom, Durham Downs, Myall Downs, Injune, Toolumbilla, Womblebank, and Mount Playfair districts.

The Upper Walloon shales and sandstones, being rather poor in lime but richer in ferruginous sandstones, often yield belts of reddish soil, not unlike that of some desert sandstones.

Yellow beds similar to the Lower Walloons and with a similar flora but of Tertiary age have been noticed in the small areas where detritus has accumulated from the weathering of the dacitic lavas of the Cracow district, a fact pointing to the possible derivation of much of the Walloon detritus from the high volcanic ranges existing in early Mesozoic times in the Dawson River country.

(*f*) *General Conclusions on the Walloon.* (*See* section, fig. 1.)

In order to construct a north-south section taking in Roma it was found necessary (so that our actual observations might be utilised) to start at Roma and run north to the base of the Cretaceous and continue the section from the base of the Cretaceous south of Minka. The section thus constructed runs approximately through Orallo and Injune Creek.

A constant dip to the south of 1 in 50 has been assumed, that being the southerly component of the dip observed wherever long exposures of sandstone occur between Orallo and Injune Creek in railway cuttings. This has been taken as the average dip, and the section is an ideal section constructed on the basis of using the average dip throughout. In point of fact we know this to be a departure from the true structure of the country, nevertheless it offers us the best means of roughly estimating the thickness of Bundamba and Walloon strata.

Actual observations gave a dip of from 7 to 10 deg. to the south in the Ipswich strata at the Moolayamber. Very flat dips were the rule between the head of the Dawson and Boxvale, a westerly dip alone was observed at Baffle Creek, but from the hills south of Baffle Creek to Hutton Creek the west-south-west dip is strongly marked with a southerly component of 5 to 6 deg. The Injune Creek country seems to lie very flat, while from the Dividing Range to near Orallo a dip of 1 in 50 was predominant. There is a flattening at Orallo, while steeper dips up to 5 and 6 deg. are met with at Yingerbay and Nareeten, and a decided flattening at Nullawurt and Minka. The general tilt to the south takes place in a series of steps, yet an average of 1 in 50 is near the mark for the strata encountered in the Roma bore, as has been already discussed under the "Cretaceous."

Comparing the Mitchell quadrant with the Roma quadrant we find that dips steepen a few miles north of Wahroonga to 10 deg., flatten out again about the Kilmorey mail-stage, and steepen north of Toolumbilla. The steeper dips north of Wahroonga correspond to those about Yingerbay, and those north of Toolumbilla to those of Hutton Creek. On Crystalbrook a gentle but general south-west dip obtains which apparently dominates also the Westgrove country to Boxvale.

(*g*) *Folding.*—In addition to the rolls discussed above there is strong evidence of other rolls on north-south axes. Thus a line north-north-west from Roma—or, perhaps better, slightly west of north from a point on the railway line a few miles west of Roma—would approximately represent the axis of a gentle anticline. Dips east of this (as on the Roma-Durham Downs road) were mostly south-south-east and south-east, while west of this south-south-west and south-west dips predominate.

A line drawn from Muckadilla to Taboonbay represents a synclinal axis, while from Amby to Womblebank is another anticlinal axis. Another gentle syncline comes in between Roma and Wallumbilla. These rolls seem to die out towards the north. The westerly dips are generally greater than the easterly ones, with the exception of those observed near in the parish of Springbrook on Selection 30, where the dips are probably accentuated by faulting. While easterly to south-east dips of 15 deg. were observed on Selection 30, a steady south-west dip of about 3 deg. obtained on the western slopes of Mount Byan Byan.

As already mentioned, no constancy of dip direction or amount of dip could be got in the Calcareous Walloon of Injune Creek and Durham Downs, where the sediments are folded into numerous small gentle anticlines and synclines by hydration and oxidation.

The bores (diamond-drill holes) for coal put down along the Injune railway have been very helpful in interpreting the geology of that region. The average south-west tilt in this region is of a very gentle nature, of the order 1 in 100.

At Mount Hutton head station fairly steep south-west dips prevail (7 deg. and over), but not far south-west of this the dip flattens out on Highland Plains and then steepens again near the head of the Bungil. So that over the Highland Plains area east of Gunnewin we also have a bench or terrace.

Occasionally, yet rarely, reversals of dip are observed.

The most striking evidence of benching is that noticed at Orallo, where a very wide terrace exists from Cornwall Station almost to Gubberimundi, some eighteen miles long and about six miles wide, as indicated by the dips noted in various parts as well as by surface topography. This terrace appears to form a nose with a north pitch.

It has already been mentioned that west of Roma near the experimental farm we get sandy soils typical of those of the Upper Walloon. South-west of this in the banks of Bungeworgorai Creek we get Cretaceous Marine beds gently rolling, but preserving an average south-west dip at nearly 6 deg., which is unusually high for these beds. East of the experimental farm near the slaughter-yard a sub-artesian bore was sunk which yielded an artesian flow at 500 ft., approximately 700 ft. higher than at Roma only two miles to the east. This seems to indicate an easterly dip of 350 ft. in the mile east of the experimental farm, while a south-westerly dip of 6 deg. has been shown to obtain west of the farm. Hence the experimental farm is on an anticlinal ridge, and the Roma bore should have been there as far as surface evidence enables one to judge.

At Forest Vale there is a very distinct bench or terrace; near Silverleaf we have another so strongly marked as to yield reversed dips in places and to form almost a dome.

Reversed dips have been noticed in the Cretaceous formations on the Maranoa River near Mitchell, which is only natural considering the conformability of the Cretaceous with the Walloon. Likewise in the Taroom and Juandah districts dips are obtainable and at least some structures can be determined by careful work, and so for the whole of the Walloon belt.

The benching and nosing which occurs so frequently is the result of the combination of the steepening of dip on the west-north-west strike with the local rolls or corrugations on the north-south strike.

The fold movements of the Walloon also affected the Cretaceous Marine, as shown by the complete reversal of the normal dip in the Maranoa River near Mitchell and in other places.

(*h*) *Faulting.*—In addition to the large fault discussed under the Cretaceous, we found indications of numerous minor and local faults. It has not been found possible to trace them any considerable length and they are not indicated on the map.

IV.—ECONOMIC RESOURCES OF THE WALLOONS.

(A) The Walloon Coals.

The economic resources of the Walloon rocks north of Roma and Mitchell consist of coal, oil shale, gas pockets, and possibly mineral oil.

The occurrence of coal in the Durham Downs district has already been mentioned (Fig. 8a).

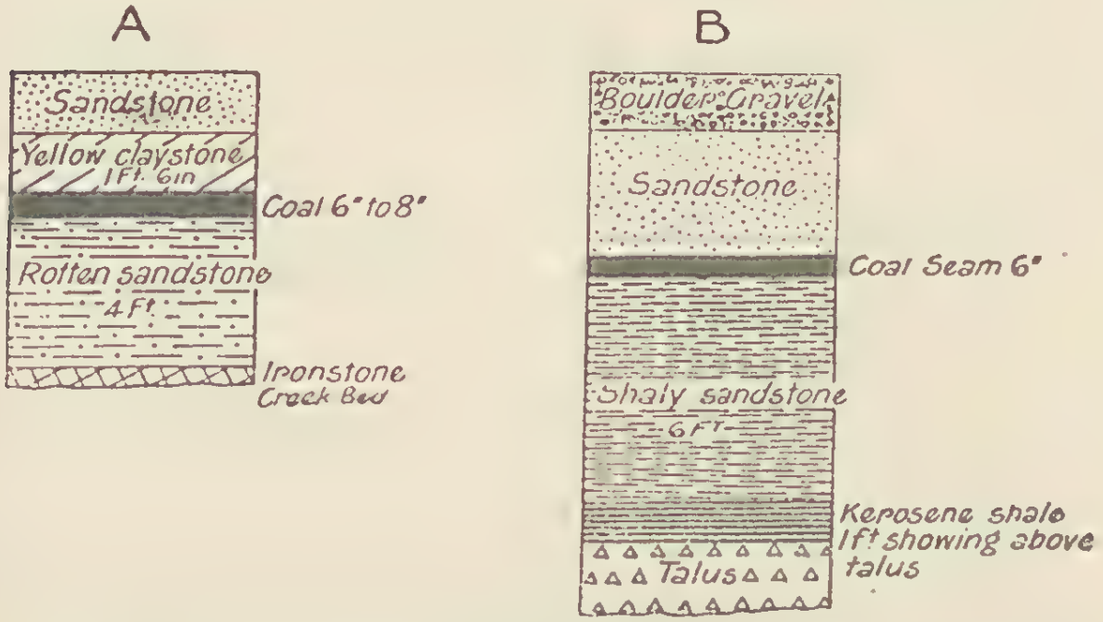


Fig. 8A.—Section in Durham Creek showing mode of occurrence of coal-seam.

Fig. 8B.—Section in Bungeworgorai Creek showing kerosene shale near Orallo.

Coal is particularly well developed in the Cornwall-Orallo-Bungil zone and in the Injune Creek zone, in both of which several seams 3 ft. and over in thickness have been recorded. The Injune Creek zone seems to offer the better prospects of the two, owing to the coal having a better average quality here and the ground being better standing ground.

In the Donnybrook-Forest Vale district north of Mitchell coal-seams up to 4 ft. thick are said to have been struck in wells, but we saw small seams only, of banded sulphurous coal.

The Lower Walloon rocks at Toolumbilla seem, on bore records and surface investigations, to contain no coal.

In general it may be stated that the Walloon coals, in common with all other Walloon beds, are highly changeable in character and thickness at various points. To form an estimate of the quantities of coal available in any seam, some trial bores are desirable. The high-grade long-flame coal which occurs in Boyd's and Ferguson's wells between the 56-mile and 60-mile, Injune line, passes under the railway and can be worked on the railway line. It lies very near the surface and can be worked by shallow workings.

(b) The Yingerbay Coals.

Mr. W. E. Cameron in 1913 visited Roma to inspect some coal workings on Bungeworgorai Creek in portion 60v, parish Bengalla, about twenty miles north-west of Roma. The coal had been opened up by a tunnel. Mr. Cameron's full report appears in the "Queensland Mining Journal," 15th October, 1913. Amongst other things Mr. Cameron says: "The coal lies nearly horizontal under a cliff of coarse friable sandstone about 40 ft. in height. It has been opened up by an open cut and tunnel in the shales above the coal, and between it and the sandstones. The coal that was exposed is represented by the following section:—Coal 5 in., clay 8 in., coal 10½ in., clay 12 in., coal 11 in., shale 16 ft."

The assays given by Mr. Cameron were—

	Middle, 10½ in.	Bottom, 11 in.
Moisture	6·42 ..	8·23
Volatile hydrocarbons ..	39·40 ..	30·82
Fixed carbon	33·16 ..	30·46
Ash	21·02 ..	30·49

We did not examine this coal-seam.

Another coal formation called Sellar's is reported to occur near Mount Beagle which is said to give the following section:—Sand and mud on top, then coal 11 in., then 8 in. shale, then coal 12 in., then shale 7 in., then coal 2 ft. 7 in. Possibly this may be the same coal formation as that described by Mr. Cameron, since seams pinch, thicken, and cut out in an erratic fashion in this series. On the other hand it may be a different coal formation in the same horizon. It is impossible to say. Another coal outcrop was noticed by us from the train on portion 2v, parish Bengalla. It seemed to be only a small 6 -in. seam.

The coals on this horizon are inferior and not of much value.

Mr. Cameron in comparing the Yingerbay coals with those obtained in the Roma bores says: "It is possible that in the 26 ft. of coal-bearing shales from 730 to 756 ft. reported by the driller of No. 2 bore, or in the 24 ft. of brown shale and lignite between 691 ft. and 751 ft. [should be 715], or the 17 ft. of brown shale with thin streaks of coal from 743 ft. to 760 ft. reported from the No. 3 bore, there is a 4-ft. seam of coal as reported by the driller of No. 1 bore at 770 ft. The variations in the reports from the three bores all sunk within a distance of 200 yds. show how unreliable are the observations of the strata in this form of drilling."

Not only are the beds in this horizon very lenticular, but

the rocks are of such a nature that different drillers would call them by different names. The mud coming to the surface from the percussion drilling of a bed of felspathic calcareous sandstone would easily be mistaken for a mud from a shale and *vice versâ*.

In his recommendations Mr. Cameron says: "The fact that immediately above the coal in Bungeworgorai Creek (on 60v, parish of Bengalla) is an apparently considerable thickness of sandstone while in the Roma bores the first considerable thickness of sandstone is between 900 ft. and 1,400 ft. and is water-bearing inclines me to the opinion that the sandstones above the coal at Bungeworgorai Creek are below the horizon of the coal-beds about the 700 ft. in the bore."

Although we found the rocks between the Cretaceous border and the Yingerbay coals predominantly sandstone we saw considerable thickness of shales interbedded at various points, and the sandstones were so largely of a felspathic nature that the muds obtained in percussion drilling would suggest shale.

One of the drillers, J. Warren, in his records from No. 1 Roma bore, shows shale to 294 ft., which would be the base of the Cretaceous shales, then sandstone to 770 ft., where his 4-ft. coal-seam comes in. The top of this sandstone series would be the Cretaceous sandstones formerly known as Blythesdale Braystone, the upper portions the Upper Walloon sandstone.

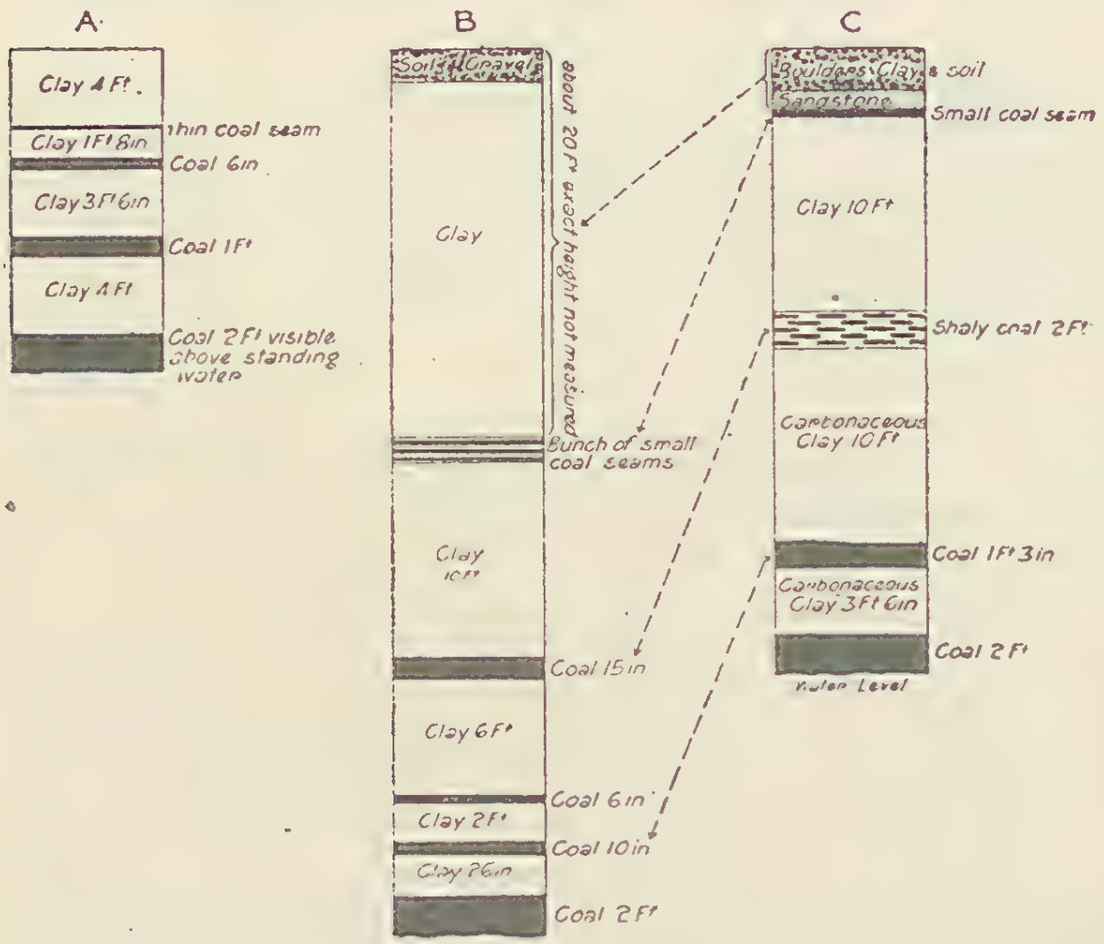
We are of the opinion that the coal horizon passed through between 690 ft. and 770 ft. in the three Roma bores in the Yingerbay coal horizon probably consists of two or more divisions each of which contains several lenticular seams of inferior coal.

The sandstones above the Yingerbay coals are very friable and disintegrate on exposure to air. This would make coal workings costly to timber if the coal-seams were workable, and constitutes a serious drawback.

(c) The Cornwall-Alcurah Coals (Oallo Measures).

The Cornwall-Alcurah coal horizon contains probably several score of seams. It is 450 ft. in thickness and consists of alternating sandstones and shales, both of which classes of rock in this horizon are so constituted that exposure to air causes them to expand and crumble to pieces. All the coal-seams are very sulphurous. Most of the coals are underlain by a thick bed of shale which in weathered outcrops is a heavy aluminous clay very suited for brick and pottery making. Owing to the crumbly nature of the strata, coal-mining in this series would require heavy timbering and even then would be risky. Most of the

junction of Bungeworgorai and Alcurah Creeks we noticed in one bank the seams shown in the section below (*see* fig. 9a).



FIGS. 9 A, B, C.—Sections showing coal-seams exposed in the banks of Alcurah Creek.

In another bank further to the west we got the exposure in a bank 50 ft. high shown in fig. 9b, and in still another bank still further west of that shown in 9c. The above two sections (b) and (c) are two banks of the same hill, or in fact two portions of the same bank separated by a slide. These banks are on Alcurah Creek and face the south. The hill is capped with a glacial (?) conglomerate. Obviously they represent the same stratum, and a comparison between these two sections probably only 200 yds. apart shows how in this coal series the coal-beds thin out, thicken, or vanish altogether.

Fig. (b) probably 200 yds. east of fig. (c).

Fig. (a) about 400 yds. east of fig (b).

The coals showing lower down the Bungeworgorai Creek are probably higher seams, there being a small but steady dip to the south-south-east in this area.

A little north of the junction of Flagstone Creek and Bungeworgorai Creek a small coal-seam shows in the main creek as below. Still lower down the Bungeworgorai north-east of the Cornwall station homestead occurs a 13-in. seam which dips

south at a very slight angle. It is overlaid by massive silicious sandstone and underlaid by clay. Lower down the Bungeworgorai the same or another very similar seam shows at the junction of Alicker's Creek. There are in fact two coal-bands separated by a seam of clay. The two bands together contain about 15 in. of coal. A sandy clay lies below and a calcareous heavy clay above the coal, and above the clay friable sandstone. Still lower down the Bungeworgorai Creek, about a mile and a-half from the railway line at Orallo and near the junction of Stewart's Creek, Mr. Dunlop observed 1 ft. of kerosene shale but another 12 in. was probably obscured by the rubble under the water, the shale occurring at the base of the escarpment. This shale analysed well for petroleum, yielding 44·8 gallons of oil per ton. (*See* fig 8b *ante.*)

On the Bungil, portions 3 and 4, parish Eumamurrin, occurs a 3-ft. coal-seam in a well at 40 ft. This is a better coal than usual on this horizon, and is probably equivalent to a basal seam in the Alcurah-Cornwall horizon.

About due east of this, on Eumamurrin Creek and on W. H. Barnes's property, it is stated that driller Chapman records 6 ft. of coal in a private bore at a depth of 150 ft. Possibly this is the same seam which has been struck here at a greater depth, owing to the flatness of the dip and the slope of the country exceeding the dip.

(d) Injune Coals.

Several beds of coal in the Injune calcareous series are recorded by Jennings in his bore on Selection 14, parish Gunnewin. These include one 2 ft. 6 in. seam of very good coal at 36 ft., a 12-in. seam at 210 ft., and a 2-ft. seam at 349 ft. These coals may or may not be identical with the coal obtained on Oakey Creek and the coal at Boyd's selection on the 56-mile. The country between these points is so soil-covered, and rock exposures so few, that one cannot make a positive statement. The dip may flatten in this region to such an extent that these seams may belong to the one horizon, but on the whole we think that Boyd's coal on Selection 105 is a lower coal than the Borehole coals, since the latter are situated near the top of the calcareous series, while the former are found near the base of the calcareous series, and also because Jennings's bore is sunk in country several hundred feet higher (about 300 ft.) than the 56-mile, whereas Boyd's coal occurs at a depth of 27 ft. or so below the bed of Injune Creek.

Coal of similar quality to that of Boyd's well and of about the same thickness has been obtained in the wells all around, as in Evans's, Hall's, and Ferguson's wells, and in the 56-mile bore at 42 ft. and 18 ft. in depth. The thickness of the seam is in all cases given as from 3 ft. to 4 ft. In Boyd's well 3 ft. of clean coal

MOUNT HUTTON

BORE SECTIONS

Scale of Feet

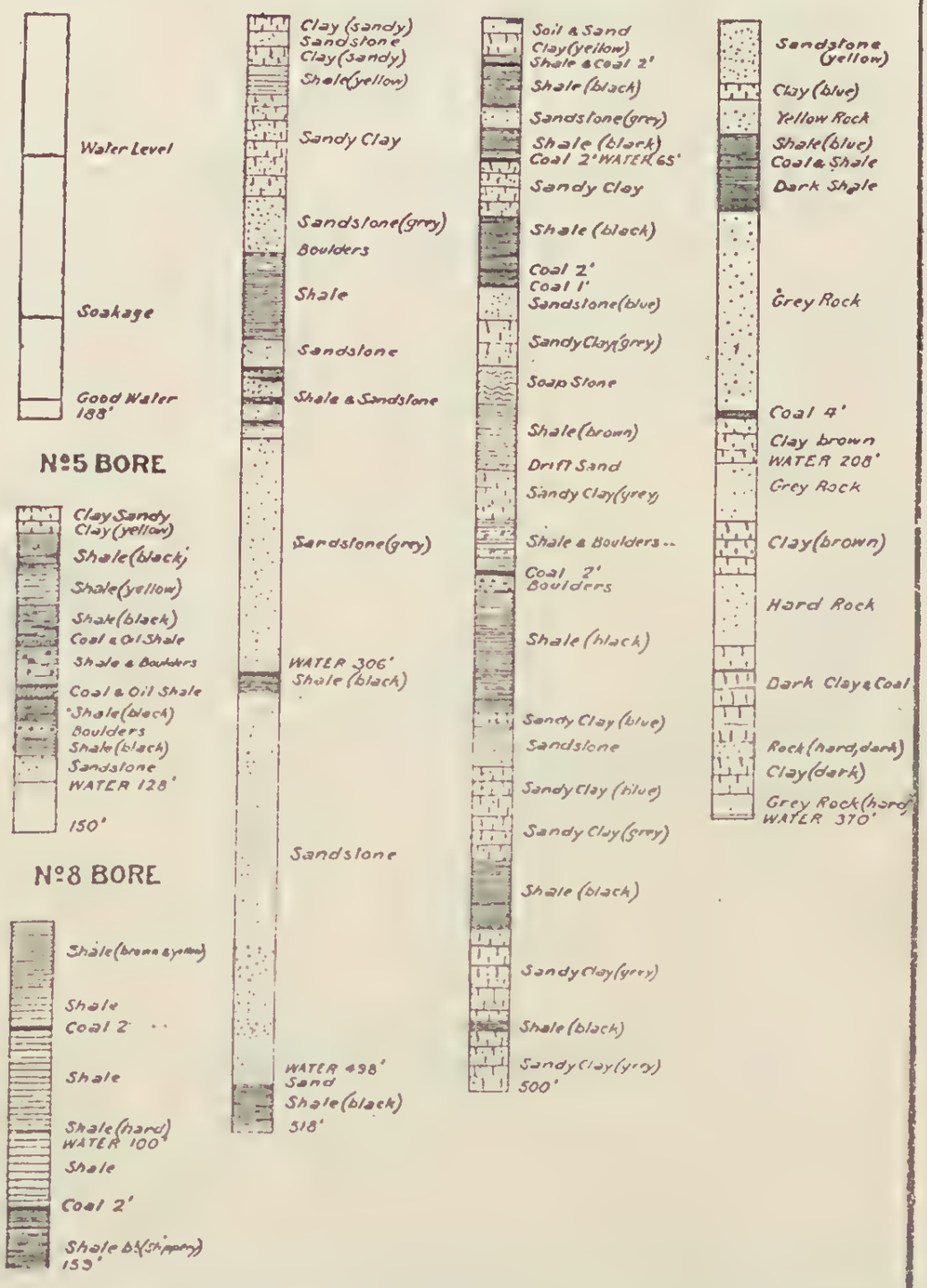
0 40 80 120 160

MOUNT HUTTON

BORE SECTIONS

Scale of Feet

0 40 80 120 160



is reported to occur, below which there is a shale-band of 6 in., then 6 in. or 1 ft. of coal below. Above the coal there are 6 in. of carbonaceous shale, then 1 ft. of white sandstone, then 11 ft. of shale, then alluvium. The well being full of water at the time of our visit, we have to rely on the data given by Mr. Boyd.

The coals similar to Boyd's we will group as the Bluey Coals:

The formations met with in Boyd's well do not crumble on exposure to air to the same extent as the formations enclosing the Almurah-Cornwall coals. The country affords better standing ground for mining purposes, and the quality of the coal is superior to that of the Cornwall coals.

The coal of Wilkinson's well in the parish of Crowman may belong to the same horizon as the Bluey Coals.

The lowest coal-bed noted was Proctor's (portion 5, parish of Crowman). (*See* fig. 10.) This is in the basal felspathic sandstones of the Walloon. As already mentioned, the outcrop showed a huge thickness but the quality was very poor. A similar large outcrop of inferior coal of the same geological horizon occurs on Laycock's selection, near the Hutton Creek cropping of the Baffle Creek road.

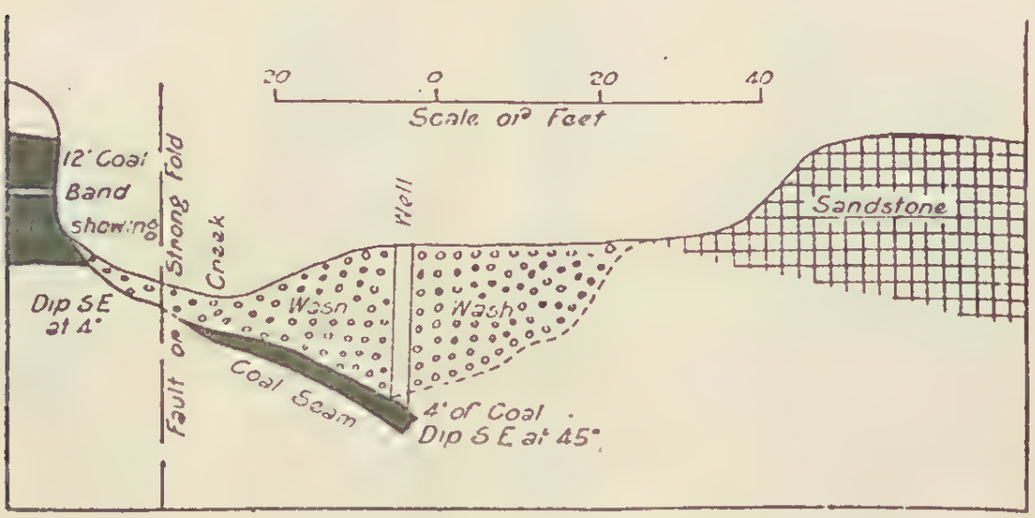


FIG. 10.—Section showing coal at Proctor's well.

The kerosene shale from the junction of Bungeworgorai Creek and Stewart Creek yielded 44·8 gallons of oil per ton.

In the Oakey Creek district two outcrops of coal were noted. They are so slightly exposed that little can be said except that they are typical Injune coals and occur in the calcareous strata.

We are indebted to the Public Estates Improvement Department for copies of their drilling records from the various bores put down for sub-artesian water in the Mount Hutton area. We

reproduce these sections, but are unfortunately unable to do much in the way of correlating the seams obtained in the different bores. (*See* Plate V., Mount Hutton Bore Sections.)

A comparison of No. 1 bore section and No. 2 section would suggest that the coal at 68 ft. 10 in. in No. 2 might be the same as that at 460 ft. 9 in. in No. 1. This interpretation agrees well with the dip to the south at about 100 ft. in a mile.

The four coal-seams met with in No. 3 bore cannot be compared with No. 1 and No. 2, as gas was obtained in No. 3 bore but was not recorded from No. 1 and No. 2, yet it is very possible that the strata pierced in No. 2 and No. 3 water bores are very near together if not the same, since the coal and shale beds are so lenticular that no reliance can be placed on their presence or absence. A comparison of No. 3 and No. 3A, only twenty chains apart, shows that several coal-seams represented in one are not represented in the other. The difference in the depth of the gas zone shows a dip of 90 ft. in twenty chains or 1 in 15 to the east if the gas is confined in the same bed in both bores. This is, however, problematical. No. 4 is in a sandstone series underlying the calcareous series, which is pierced by No. 3 and 3A. Water could be obtained in the latter by going deeper. The coal in No. 5 bore may belong to the same horizon as Nos. 3 and 3A, but it may be lower. If it is the same the coal would probably be equivalent to that got at 400 ft. in No. 3 bore.

The coal in No. 10 water bore cannot be correlated with the other bores. Nor is it possible to correlate bores 6, 7, and 8 with the others or one another.

Diamond Drilling.

Six bore-holes, D.D. Nos. 1 to 6, have been sunk to test the quality and nature of the coal measures. Their locations are as follows:—

No. 1 D.D., Bluey Creek, parish Injune.

No. 2 D.D., parish Injune.

No. 3 D.D., parish Injune, twelve chains north-north-east of D.D. 2.

No. 4 D.D., Barramundi Creek, Komine Common.

No. 5 D.D., parish Injune.

No. 6 D.D., parish Gunnewin.

These sites are marked on Plate II.

The drilling shows that the seams pinch rapidly, that the standing ground is poor where the coals are best, and that none of the seams pierced are large. The best seams were the 3 ft. 6 in. and 4 ft. seams in Nos. 2 and 3 bores.

Nevertheless, as a result of diamond drilling the Lower Walloon Series has been proved extremely prolific in seams of coal and oil-shale. The want of consistency in thickness of the seams was evidenced by the sections of bores 2 and 3.

An interesting feature of the series is that the shales overlying the coals and lying between adjacent coal-beds are usually oil-shales, containing sometimes a little free oil as well as shale oil.

The sequence from above down is usually—

Shale.
Hard calcareous band.
Oil shale.
Coal.
Porous oil shale or sandy shale; no oil.
Shale without oil.
Hard calcareous band.
Oil shale.
Coal and so on.

A number of tests of the cores was made to determine this sequence, which was considered by Mr. Milsom as characteristic of strata in which downward migration of oil has taken place. In the Middle Walloon Coal Measures the coals are usually overlain by black or yellow aluminous shales containing pyrites and no oil.

Pyrites also occur in some of the shales of the Lower Walloon, but is more common in the Basal Walloon sandstones.

The coals are remarkably consistent in character, and no doubt in time to come many of the larger seams will be worked.

Table B gives the analyses by the Government Analyst of a large number of coal samples. The analyses show that these coals are remarkably like the Walloon coals in other parts of the State. (*See* Table A.)

In both tables the carbon ratios have been computed, since they will be referred to in the paragraphs dealing with oil.

From the diamond drilling and the failure to obtain the same succession even in neighbouring bores it is obvious that the Walloon strata of Injune Creek are very lenticular, and the lenticularity applies even to the coal-seams. Without very much more drilling than has been done it is impossible to correlate the beds met with in different bores. The large coal-seams recorded in the log of the Gunnewin sub-artesian bore are altogether absent in No. 6 diamond-drill hole near Gunnewin, pointing

either to extreme lenticularity in the seams or to faultiness in the sub-artesian drill records.

TABLE A.—COMPARISON OF IPSWICH AND WALLOON COALS FROM DIFFERENT DISTRICTS.

—	Roma District. Walloon, Av. of 8 Analyses.	Ipswich Coals, Av. of 6 Analyses.	Kingston, Logan, Ipswich, Av. of 3 Analyses.	Beaudesert. Walloon, Av. of 6 Analyses.	Rosewood. Walloon, Av. of 27 Analyses.	Lockyer. Walloon, Av. of 2 Analyses.	Darling Downs. Walloon, Av. of 11 Analyses.
Moisture	5·9	1·6	1·6	4·5	4·8	6·0	4·6
Volatile hydrocarbon	40·9	29·6	23·6	36·3	37·0	33·7	38·4
Fixed carbon	43·3	59·0	52·2	43·0	46·1	46·8	41·4
Ash	9·9	9·8	22·6	16·2	12·1	13·5	15·6
Total	100·0	100·0	100·0	100·0	100·0	100·0	100·0
Carbon ratio	51·4	66·6	68·9	54·2	55·4	58·1	51·9

List of Localities for Coal Analyses in Table B.

1. Bottom seam, junction of Bungeworgorai and Alcurah Creeks, Cornwall-Orallo district.
2. Alicker's Creek seam, Cornwall head station.
3. Bungil Creek, por. 3, par. Eumamurrin, 4 ft. coal in well.
4. Wilkinson's well, por. 3, par. Crowman.
5. Proctor's seam, por. 5, par. Crowman.
6. Ferguson's well, por. (?), par. Injune.
7. Reid's 7-ft. seam, por. (?), par. Injune.
8. Riche's well, 5-ft. seam in bore at 95 ft., por. 56, par. Eumamurrin.

Diamond Drill holes—

9. No. 2, 118 ft. to 122 ft.
10. No. 2, 166 ft. 6 in. to 169 ft. 6 in. } Bluey Creek.
11. No. 3, Injune, 88 ft. to 91 ft. 6 in.
12. No. 3, 113 ft. 6 in. to 115 ft.
13. No. 3, 118 ft. to 119 ft. 3 in.
14. No. 3, 124 ft. 8 in. to 128 ft.
15. No. 4, 253 ft. to 254 ft.
16. No. 4, 306 ft. to 307 ft.
17. No. 4, 376 ft. 6 in. to 379 ft.
18. No. 5, 173 ft. 6 in. to 177 ft.
19. Lyon's well (53 ft.) bottom.
20. Kehl's Selection, Taroom.

Note.—Excepting Nos. 1, 2, and 3, the above are all Lower Walloon Coals.

TABLE B.—WALLOON COAL ANALYSES, ROMA-INJUNE DISTRICT.

——	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Moisture ..	7·4	7·3	7·1	5·3	6·8	5·0	4·7	6·3	2·6	3·3
Volatile hydrocarbon	33·8	29·7	44·0	43·7	38·7	40·5	39·0	39·7	43·1	38·6
Fixed carbon	34·4	30·2	43·2	40·2	37·5	49·7	49·3	46·1	42·0	41·4
Ash ..	24·4	32·8	5·7	10·8	17·0	4·8	7·0	7·9	12·3	16·7
Total ..	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0
Carbon ratio	50·4	50·4	49·5	43·1	49·2	55·1	55·8	53·9	49·3	51·7
Coking test	..	..	..	..	..	..	Non-coking	..	Hard, brittle coke	Soft, inferior coke
Calories per kilo	..	..	..	..	..	..	6,745	..	6,742	6,408
British thermal units	..	..	..	..	..	..	12,141	..	12,136	11,534
Lb. of water evaporated at 212° F. by 1 lb. of coal	..	..	..	..	..	..	12·6	..	12·6	11·9

——	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.
Moisture ..	3·5	4·3	3·5	4·6	5·9	5·9	4·5	2·0	3·0	2·7
Volatile hydrocarbon	37·6	40·2	42·3	33·4	38·1	36·5	38·1	42·8	41·3	46·5
Fixed carbon	38·6	48·0	47·9	40·5	49·3	51·7	47·5	35·3	40·0	43·6
Ash ..	20·4	7·5	6·3	21·5	6·7	5·9	9·9	19·9	15·7	7·2
Total ..	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·00
Carbon ratio	50·4	54·4	53·1	54·8	56·6	58·6	55·4	45·2	49·2	48·4
Coking test	..	..	..	..	..	..	..	..	..	..
Calories per kilo	..	..	..	..	..	..	..	6,371	6,455	..
British thermal units	..	..	..	..	..	..	..	11,468	11,619	..
Lb. of water evaporated at 212° F. by 1 lb. of coal	..	..	..	..	..	..	..	11·87	12·03	..

V.—OIL PROSPECTS OF THE WALLOON.

(A) SUMMARY OF THE GENERAL GEOLOGY OF THE WALLOON.

In Q.G.S. Bulletin 247, p. 17, Mr. W. E. Cameron estimates the dip of the Trias Jura beds under the Roma region at between 150 and 200 ft. in the mile towards the south. In the present investigation the average southerly dip in large areas of massive sandstone on the Dividing Range north of Orallo was found to be somewhere between 1 in 45 and 1 in 50—i.e., between 105 and 120 ft. in the mile. Observations in the field on Crystalbrook and Eddystone Vale Stations gave the southerly factor of dip as 60 ft. in the mile for this region.

In a section prepared an average dip of 1 in 50 (fig. 1), or about 100 ft. to the mile, to the south was assumed. It was noticed that this b..ngs the gas zone at the bottom of the Roma bores into the heart of the Injune Creek coal area or Lower

(Calcareous) Walloon division. In fact, the Roma gas zone seems nearly to coincide with that of the "bore-hole coals" passed through between the surface and 400 ft. in depth in Nos. 3 and 3A water bores on Mount Hutton subdivision, about eight miles west of the 51-mile on the Injune railway. A comparison of the strata passed through in these bores and those of the Roma bores shows that both consist of a rapid alternation of shale, carbonaceous shale, sandstone, and limestone, with occasional hard streaks, cements, &c., with this difference, that the Injune sections show frequent intercalations of coal as well. The rapidly changing nature of the deposits indicates formation under estuarine and deltaic conditions, therefore favourable for the production of oil. The two Injune Creek bores referred to also yielded gas, which, however, on analysis, proved to be coal gas.

Inasmuch as Cunningham Craig has shown in the case of the Trinidad field, and other geologists for other fields, that a coal series may within a few miles change into an oil series, there is no objection to the correlation of the Injune Creek coal-beds with the Roma gas-zone. In fact, all the geological evidence collected points to the identity of the two zones. Thus, the rocks actually met with in the field passing north from Roma, and plotted on a section assuming the average dip of about 100 ft. to the mile, give us almost the same thickness of each horizon passed through as in the Roma bores.

In reality the dip is not as regular as assumed above. Field-work shows that the entire region is folded into gentle anticlines and synclines on approximately north-south axes, and that there are a series of monoclines and flattenings, or terraces passing from south to north which have developed on east-west axes.

Roma is near the axis of a gentle anticline, but would appear to be slightly (perhaps three to four miles) east of the actual centre. A broad syncline has its centre near Muckadilla, as shown both by the curvature of the Cretaceous Walloon border north of Muckadilla, and by the section of the Muckadilla bore. Another anticline has its axis a few miles west of Amby, but there are indications of a severe north-south fault, with down-throw to the west, between Amby and the sharp bend in the Dividing Range. This downthrow moves the boundary between the Cretaceous and Walloon many miles north of where it otherwise would be.

As regards the monoclines or terraces, there is a very decided flattening of dip at Orallo and Cornwall about thirty miles north of the Western Railway. There is a slight increase in dip from the 35-mile to the 50-mile, and a great flattening between the 50-mile and the 62-mile on the Orallo line. The dip steepens again north of Injune Creek, and noticeable dips are frequent as far as Baffle Creek and Westgrove, but the beds lie almost horizontal in the Dawson River near Boxvale and north

of Boxvale to the Carnarvon Range. In this range they steepen very considerably, the southerly component often exceeding 6 deg.

(3) A Comparison of Western Queensland with the Midcontinental Oilfield of the U.S.A.

The structure, to recapitulate, is that of a gentle monocline dipping from north to south in the Roma district, and from north-east to south-west in the Maranoa basin. This monocline is, however, not a quite regular inclined plane, but it is gently folded into terraces by the dip steepening in certain belts at right angles to the dip and flattening in other parallel belts. It is also wrinkled by gentle folds in the direction of dip. Owing to the soil-clad nature of the country, the accurate determination of anticlinal centre lines must be regarded as a matter for drilling, the fieldwork only enabling one to determine the anticlines approximately. The average dip in the region north of Roma was shown to be about 100 ft. in the mile, and in the Maranoa district about 60 ft. in the mile, and in both cases local steepening to 3 deg. (270 ft. per mile) or even 6 deg. equal to 570 ft. per mile occurring in certain belts, and local flattening to 100 ft. in the mile or even to no dip at all in other wider belts.

The nature of the strata in the Lower Walloon was shown to be highly carbonaceous deltaic deposits very favourable for oil production, and the porous sandstones both above and below this series were very suitable sands for the storing and preservation of oil.

It has also been contended by the writer that the best depth to search for oil is at and about 2,000 ft., because great depths entail high pressure and high temperature, and under the ordinary laws of physical chemistry liquid petroleum would under high temperature and pressure tend to disintegrate into gaseous and solid components, while in shallow ground the liquid petroleum is forced down into deeper ground by water pressure.

Since the previous article was written, the writer has perused Dr. Bosworth's Geology of the Midcontinental Oilfields, and finds that this area is remarkably similar in most respects to the Roma field. The main difference is one that does not matter—viz., one of geological age—the Midcontinental field drawing its oil supplies from the Lower Palæozoic and Permian strata while those we would expect in the Roma district would be drawn from the Jurassic on underlying Bundamba grits.

The Midcontinental Oilfields, consisting of the four States of Kansas, Arkansas, Oklahoma, and North Texas, have produced 1,266,558,334 barrels of oil, of the 8,057,000,000 barrels which constitute the world's output to-day, or nearly one-sixth of the world's production, and one-fourth of the total production of the United States.

The field differs from most other oilfields in this respect, that seepages of oil on the surface and in wells were almost completely absent. The only surface manifestations were of a few tarry seepages near the Wichita Mountains, and some asphaltum-bearing sandstone in the Arbuckle Mountains. Yet so rapidly did the exploitation of this field expand that between 1914 and 1918 the total number of wells drilled is about 110,000, thousands of which reach a depth of 3,000 ft. In 1918 alone 12,843 bores were put down. Dr. Bosworth says on p. 27: "The deep drilling which has now become necessary in the Mid-continental Region makes failure very costly."

Such aid as *geology* can give is being utilised on a large scale by leading companies, and hundreds of skilled *geologists* are employed.

In dealing with the general structure of the region Dr. Bosworth describes the entire field as a monocline tilted westward and dipping at 10 to 50 ft. per mile, the average being 20 to 30 ft. per mile. However, in the Garber oilfield, which is a part of the region, the average dip is 100 ft. per mile, and in another subdivision known as the Glen oilfield the average is between 50 and 100 ft. per mile. Now it should be remarked that these dips are strikingly near the dips observed in the Maranoa, and in our Western Queensland artesian basin which conformably overlies the petroliferous Jurassic rocks.

The writer has found that the very excellent bore sections published and compiled by the Queensland Hydraulic Engineer's department are an invaluable aid to a geologist in determining the geological structure of our artesian basin. Although the data are often faulty through the head-driller's frequent lack of scientific knowledge, they can usually be interpreted by a geologist who is acquainted with our Western formations. One thing is particularly noticeable—viz., that the basal beds of the Cretaceous consist of a thick series of calcareous mudstone and shale, which is usually termed "blue shale" or "dark shale" and sometimes "black shale" by the drillers. This series is from 500 to nearly 4,000 ft. in thickness; though the upper and middle zones of the Marine Cretaceous may contain interlaminated sandstones and grey shales, the lower 500 ft. is almost invariably blue shale. From this blue shale we pass into quickly alternating beds of sandstone, grey shale, brown shale, pipeclay, carbonaceous beds, and water sands. These constitute the topmost Walloon strata.

It is also noticeable that the Jurassic beds under the blue shale in South Queensland are largely white sandstone, felspathic sandstone with white pipeclay, and light-coloured shale bands, while in North Queensland the Jurassic beds underlying the Marine in the bores are red sandstone and red clays—a feature perfectly consistent with the observed outcrops, which in South Queensland are white, grey, and generally light-coloured, while

in the Northern districts our plateau sandstones, as between Hughenden and Charters Towers, Mount Mulligan and elsewhere, are dominantly reddish. The bore sections consequently give added proof that many of our plateau sandstones throughout the State are Jurassic as Mr. Dunstan has emphasized on stratigraphical evidence, and not "Desert Sandstone" (Upper Cretaceous) as formerly supposed by early geologists. However, their redness in North Queensland indicates deposition under arid conditions.

Adopting these facts as a criterion for determining the base of the Cretaceous in bore sections, the writer has arrived at the following dips which can be greatly extended:—

	Ft. per mile.
1. Mitchell south-west to Oolandilla	90
2. Roma west to Muckadilla	70
3. Mitchell east to Muckadilla	70
4. Roma south-south-east to Surat	40
5. Afton Downs north-north-west to Surat .. (Surat appears to be in the centre of the geosyncline)	40
6. Redford west to Nive Downs	15

Without going into further details, it has been made sufficiently obvious that the dips under our Western plains are closely approximate to those obtaining in the Midcontinental oil region of America.

The general direction of dip of the monocline under our Western plains is south-west and in the Roma segment south. Unlike the Midcontinental oilfields, our West has an artesian water series overlying the petroliferous series which has no doubt hindered the discovery of oil, water pressure in the bores having dammed back the oil.

Like the Midcontinental field of America, our Western sedimentary series has been laid down on an irregular eroded surface, so that ridges of palæozoic rocks are here and there struck in bores or met with in outcrop. Thus serpentine and asbestos occur at Eddystone Vale near the head of the Maranoa entirely surrounded by sandstones of Mesozoic age; a granite schist patch is said to occur at the head of the Warrego where it is surrounded by artesian springs; and Palæozoic schists were struck in the Morven bore at a depth of a little over 2,000 ft. These occurrences are evidence of a ridge of metamorphics striking north-south under the Mesozoic rocks of this region, and are analogous to the buried ridge under the Nemaha Mountains near which an important oilfield is located.

Dealing with minor structures on the Midcontinental monocline, Dr. Bosworth remarks: "By detailed survey work it was found that the monocline is not a perfect plane, but is wrinkled

with very slight undulations, more or less parallel to the line of strike, and also sometimes with irregular corrugations along the direction of dip. The dip of the rocks on either flank of the undulations rarely exceeds 1 or 2 deg., and so these anticlines are not easily perceived. Often indeed this dip is not sufficient to neutralise the general dip to westward pertaining to the monocline, and thus the flexure does not amount to the anticline at all, but may be called a terrace. It is on these anticlines, domes, and terraces that the accumulations of oil occur."

It will thus be noticed that even in minor structures the geology of the two regions is closely similar. Even in the matter of uplifts we can find parallels: thus the Walloon Series comes in at a depth of only a few hundred feet at Morven where on a constant dip they should be thousands of feet down. The buried ridge in this region has evidently caused a fold in the overlying strata comparable to the Red River Uplift in Texas.

A comparison of the strata passed through in the Mid-continental series (p. 88 in Dr. Bosworth's book) with the strata passed through at Roma shows the sediments in these two vastly remote regions to be similar in nature. The Cherokee series has yielded the greatest quantities of oil and is described as "shales, sandstones, thin limestone, workable coal, and the principal oil sands." This description (omitting the last item, which has not yet been fully demonstrated for Roma) would adequately depict the Injune Creek coal measures of the Lower Walloon to which the Roma bore is now sunk. Even in regard to "workable coal" the two series are analogous. It affords an interesting speculation whether the oil is the result of the gradual transformation of long-flame coal, like our Walloon coal, into short-flame coal with liberation of hydrocarbons.

The principal oil sand is in the Cherokee formation and is known as the "Bartlesville" sand. Dr. Bosworth, between pages 95 and 102, gives a series of tables in which he shows what sands have yielded most in each country, and from what depths. A study of those tables convincingly shows that the most prolific yields are from depths of from 1,500 to 2,500 ft., and that the same sands become less petroliferous below as well as above those levels, though at greater depths than 2,500 ft. very many of the greatest gas-flows have come from bores.

The poor yields on shallow ground are probably due to water pressure forcing the oil into deeper levels, and, as already stated, the high gas yield and lower oil yield of the deepest levels on this field are probably the result of high temperature and pressure exceeding the critical temperature of liquid oil. In Queensland the temperature of our Western plains sedimentary series is much higher than one has a right to expect for the depth, if our artesian waters can be taken as a gauge of the temperature of the beds from which they are drawn.

This fact has been repeatedly stressed by advocates of the

Plutonic origin of our artesian waters, such as Gregory, Symmonds, Du Toit, and later Dr. Richert (*see* Roy. Geog. Soc. of Australasia, vol. for 1920). Hence gas would be expected to supplant liquid oil at shallower depths than elsewhere. In great geosynclines of recent formation like California, the isogeotherms are depressed, hence oil in large quantities has been obtained from greater depths.

Just as the petrol gases can be recombined into liquid petroleum under pressure at ordinary temperature, so under excessive temperature it seems only natural that liquid petroleum should be transmuted to gases. Gases are more compressible than liquids. It has been shown by Johnson and Huntley that petroleum gases rising upward along fault-planes and entering sands at higher levels recombine in the liquid form under suitable temperature pressure conditions. The laws relating to partial pressures and critical temperatures seem yet to require considerable study and application in relation to oil.

There are several interesting problems which will yet have to be studied in Australia in regard to the origin of oil, and the effect of its formation on our artesian waters. It requires to be ascertained whether gassy coals become carbonised in time with liberation of hydrocarbons, whether such hydrocarbons recombine in higher and lower strata to form oil, whether such reactions are exothermic or endothermic, and whether such changes in our coals can have anything to do with the high temperature of our artesian waters. Also there is a time factor in the production of oil: has water anything to do with it and what temperatures and pressures are most favourable? Is the pressure behind our artesian water partly the result of gas pressure behind or below it? These and many other avenues of investigation will be opened up if we strike payable oil, and our oil problems and artesian problems will be found to be closely interwoven.

Investigations of an analogous nature in America have led to the formulation, by Dr. David White, of a theory which from its satisfactory application in West Virginia has become known as White's Law. Dr. Bosworth considers that it also applies in the Midcontinental fields, and defines the law as follows:—

> (1) "In regions where the progressive devolatilisation of the organic deposits in any formation passed a certain point, marked in most cases by 65 to 70 per cent. of carbon (pure coal basis) in the associated or overlying coals, commercial oil pools are not present in that formation, nor in any formation normally underlying it, though commercial gas pools may occur."
>
> (2) "The lowest-rank oils of each type are found in the regions and formations in which the carbonaceous deposits are least altered; the highest-rank oils being, on the whole, found in regions where the carbonaceous deposits have been brought to correspondingly higher ranks."

Dr. Bosworth continues: "The idea underlying the laws is that there has been a progressive chemical change among the hydrocarbons, as with the coals under the influence of time and compression."

According to Johnson and Huntley, "The increased dynamo-chemical activity with increased depth and folding produces a continuous evolution of gas and oil from organic detritus, and to a much less degree of *previously formed oils* that the quantities become increasingly gaseous, and those that are liquid lighter and lighter, as the dynamo-chemical agency becomes more intense."

Thus heavy oils characterise formations with gassy low-grade coals, and light oils those formations in which the coal is high in fixed carbon.

These results are of great interest and importance to us here in Australia.

In accordance with White's law we might expect considerable oil pools throughout our Jurassic strata in the West. The most carbonaceous horizons are in the Middle Walloon (Orallo coal measures) and Lower Walloon (Injune coal measures), especially the latter, the Upper Walloon being chiefly remarkable as the source of our artesian waters. The main carbonaceous zone is about 2,400 ft. below the principal water zone. On White's law, our Walloon being not intensely folded and containing gassy coals should contain mostly heavy oils, except where enormous thicknesses of superincumbent strata have created dynamo-chemical forces generating gas and light oils. It is on Johnson and Huntley's theory quite likely that gas only will be met with at great depths.

By receding northwards towards the edge of the basin and boring say in the region of Orallo, we will not only strike the petroliferous beds at a depth of about 2,000 ft., which seems ideal for oil preservation, but we have the additional advantage of commencing boring in drier strata, viz., in the outcrop of beds underlying the principal artesian water zone and overlying the principal petroliferous zone.

The writer hopes that sufficient has been said to demonstrate to the public that private enterprise has great opportunities here in Queensland in the search for oil, and that the Roma bore, even if it fails to locate liquid petroleum, has been of great value to intending oil-prospecting companies in enabling better localities for future drilling to be picked.

The analogy between the geology of the Midcontinental Region of the U.S.A. and our Western probable oilfields is so striking, that is will be a veritable wonder if private enterprise does not commence operations. Every bore put down will help to determine geological structure more accurately, and hasten development. The world moves on oil. The demand for oil is

steadily increasing and American supplies are so rapidly dwindling, that American scientists are already working on the problem of finding a new source of power and on the problem of producing oil from coal. Oil to-day creates empires. It is the modern wealth of nations. Instead of relying wholly on one experimental bore, we should have hundreds in progress. Success is more likely to follow if boring is carried out in shallower ground than Roma.

It is no wonder that oil has not been met with more frequently in our artesian bores, as the water pressure invariably dams it back. It is rather a wonder that oil products have been found at all as in the Bimerah, Springlea, and other bores. In the region close to the outcrop of our probable petroliferous beds only shallow sub-artesian bores have been sunk, as this region is usually high ground, too high to expect artesian flows. By shutting off each water-flow as it is met with, and boring almost dry, and by paying more attention to the higher grounds round the edge of our artesian basin, oil-propecting should soon result in some successful hits.

(c) Evidences of Oil in the Lower Walloon Series.

1. The occurrence of "wet" gas in the Roma bore where the upper beds of the Lower Walloon Series were met with at a depth of about 3,600 ft. The significance of this wet gas has already been ably dealt with by Mr. W. E. Cameron (Q.G.S. Pub. 247 and Q.G.M.J., vol. 7, p. 239, 1906) and Mr. J. B. Henderson (Jour. of Roy. Soc. of Q., vol. xxxii., p. 53, 1920).

2. The occurrence of fatty, inflammable, and very light substance in the Lower Walloon beds at Boggarella as noticed by Messrs. Cameron and Godfrey, artesian drillers (*see* Q.M.J. April 1922).

3. The general salinity of the Injune Creek series as demonstrated by the vegetation (*see* Q.M.J. March 1921, and Agr. Jour. 1921), and by saline efflorescences on rocks in many places in the belt.

4. The occurrence of mound springs along the outcrop of the porous sandstones immediately underlying the probable oil-producing beds, as at Mount Hutton, Timor, and Crystalbrook.

5. The occurrence of oil shale in association with the Walloon coals of the Lower Walloon belt, a matter which will be discussed more fully below.

6. The composition of the Lower Walloon coals.

7. The calcareous nature of many of the Lower Walloon sandstones and shales, indicating deposition in a relic sea partly salty like the Caspian Sea to-day. The deposits are not truly continental or freshwater.

8. The strong salinity of the water in the Mount Hutton bores and the occurrence of a saline spring a few miles north of Mount Hutton Station.

9. The highly carbonaceous nature of a thick series of shales in the Lower Walloon aggregating 700 ft.. in thickness. This might tentatively be called the Injune Creek horizon. These shales are very rich in vegetable remains.

10. The occurrence of bands of "burnt" shale—porcellanitic shale—south of the Dividing Range on the Injune railway.

11. The shallow-water and near-shore conditions under which the Lower Walloon beds were deposited, as instanced by their lenticularity.

12. The rubbery nature of many of the blacksoil belts in the Lower Walloon comparable to the so-called paraffin "dirts" of Texas.

Kerosene Shale (Oil Shale) and Torbanite as an Indication of Petroleum.

Mr. Cunningham Craig, in "Oil Finding," 1920 edition, on p. 212, remarks that "oil shales may still be regarded as an indication of petroleum," and gives reasons for that belief. On p. 217 he states, "consequently torbanites are in a sense indications of petroleum." He regards oil shale due to absorption phenomena caused by the affinity of certain argillaceous deposits for petroleum. The petroleum thus absorbed is a polymerised concentrated form. In the oil shale there is a combination between the disperse phase of the colloid solution (whether col or gel) known as crude oil and the mineral colloids of fine clay. The fact that in most oil shales the oil is in a polymerised condition Mr. Cunningham Craig considers due to decrease of temperature, by the strata being brought closer to the surface by elevation and erosion.

In the Carnarvon Range area we have torbanites in the Middle Walloon coal measures, oil shales in the Lower Walloon coal measures, and torbanites again in the Upper Bowen strata at their outcrop, north of the Carnarvon Range in Carnarvon Creek.

Torbanites are regarded by Mr. Cunningham Craig and other modern petroleum authorities as different in origin from oil shale, the former having had its oil content generated from the organic matter in the same bed, that is *in situ*, while the latter has derived its oil by a migration of oil generated in other beds into aluminous clay beds.

On the theory advanced by Cunningham Craig that the gels of kerogen in oil shale are formed by the polymerisation

of polycyllical hydrocarbons due to reduced temperatures consequent on erosion and elevation, it is likely that the strata which appear as oil shale on the outcrop will, at depths of 1,000 ft. and over, pass into strata carrying commercial oil pools.

The Effect of High Temperatures on Oil.

Since Mr. Moore, the driller in charge of the Roma bore, has noticed an increase in temperature in the Roma bore of one degree for every 36 ft. of descent, it is apparent that the temperature at 4,000 ft. may be considerably over 180 deg., and at 3,600 ft., the zone where the great gas supplies were met with, the temperature would lie between 160 and 180 deg.

The effect of high temperature on oil is that a decomposition known as "cracking" is brought about, and that when the heat is applied at atmospheric pressure an increase in the percentage of unsaturated hydrocarbons is brought about, and loss of hydrogen. The unsaturated hydrocarbons tend to polymerise and form "inspissated" petroleum-kerogen.

What the effect of high temperature accompanied by great pressure might be on oil can only be surmised, but from the ordinary laws of physics—the laws of compressibility of liquids and gases—it is reasonable to suppose that at depths such as 4,000 ft. in the Roma area we would expect oil to be resolved into solid and gaseous components.

From the foregoing, it is evident that the most favourable zone for obtaining oil in the Walloon belt by drilling is where the probable petroliferous beds are met with at a depth of from 1,000 to 3,000 ft.

The Association of Coal and Oil.

Many drillers through their experience on certain new oilfields contend that the petroliferous strata always lie below the coals, and that oil does not occur above coal. Sections given by Dr. Bosworth in "Geology of the Midcontinental Oilfields" show that often we have coal above oil, and more coal below the oil. In the "Geology of Petroleum," by William Harvey Emmons, Ph.D., 1921, more instances are given. On p. 217 he says: "In the Pennsylvania West Virginia area oil is found both above and below coal in the Pennsylvanian series and in the Mississippian and Devonian."

The occurrence of coal in the Middle Walloon, Lower Walloon, and Permo-Carboniferous of the Carnarvon Range area does therefore not in the slightest preclude the possibility of getting oil in these formations and between them.

Myron L. Fuller in an illuminating article "Carbon Ratios in Oklahoma Coals," Economic Geology, vol. xv., No. 3, April and May 1920, shows by a comparison of thousands of analyses of Midcontinental coals that the most prolific oilfields lie in the

areas in which the carbon ratio (the percentage of fixed carbon in pure coal, eliminating moisture and ash) lies between 50 and 55. In the same article he gives a map of the Midcontinental field which shows that all the greatest producing areas lie between the isovolves (lines joining places with coal of equal carbon ratio) of 50 and 55.

The Walloon coals of Queensland have the carbon ratio mostly between 50 and 55. So, not only is the Lower Walloon belt of our Central West structurally like the Oklahoma field, but the character and composition of the coals of that belt are the same as in the most productive oilfield of the world, and one which showed no surface indications whatever of petroleum. The Walloon coals in general have a composition approximating—

	Per cent.
Fixed carbon	40
Volatile hydrocarbons	40
Ash and water	20

The coals collected at surface outcrops have generally lost some of their volatile hydrocarbon, for which allowance must be made.

Some typical coal samples collected by the writer in the country north of Roma, and analysed by the Government Analyst, gave carbon ratios very near the ideal for an oil-producing area. (*See* Table under section on Coal.)

Recently it has come to the knowledge of the writer that a 7-ft. coal-seam exists at the head of Sardine Creek in the Carnarvon Range. This is the first record of a coal-seam in the Ipswich strata in that part of Queensland.

The carbon ratio of the Ipswich coals in the Moreton district is high, generally over 65 per cent. Mr. Myron Fuller gives the relation of carbon ratio of coal to oil production as follows:—

Carbon Ratios (Surface).	Production.
Over 70	No oil or gas, with rare exceptions.
65 to 70	Usually only "shows" or small pockets. No commercial production.
60 to 65	Commercial pools rare but oil exceptionally high-grade when found. Gas wells common but usually isolated rather than in pools.
55 to 60	Principal fields of light oils and gas of the Appalachian fields.
50 to 55	Principal fields of medium oils of Ohio-Indiana and Midcontinental fields.
Under 50	Fields of heavy coastal plain oils and of unconsolidated Tertiary or other formations.

This, if applicable to Queensland, should cut out the Triassic of the Ipswich-Moreton district as a likely oilfield, but, although the coal from the Ipswich formation in the Carnarvon Range has not been analysed, it is safe to say that the carbon ratio

will lie between that of the Walloon and Bowen coals of that area, and will be between 55 and 60 per cent., hence favourable for fair oilfield development.

The coals of Permo-Carboniferous age of the Dawson Valley are more anthracitic than those of the same age on Consuelo and Carnarvon Creek as a result of the greater orogenic disturbances in the eastern area.

The following are the carbon ratios of the coals collected by the writer in the Permo-Carboniferous north of the Carnarvon Range:—

——	Carnarvon Creek.	Consuelo Creek.
Volatile matter	31·1	29·8
Fixed carbon	53·9	52·3
Carbon ratio	63·4	63·9

Allowing for loss of volatile through these samples being weathered outcrop material, it is evident that there are oil possibilities both in the Upper Bowen and Middle Bowen coal measures in this area, and in the Ipswich formation of the West as well.

The Oil Shales in Association with Coal near Injune.

In Lyons's well, about two miles south-west of Orallo railway station, oil shale overlies coal. Mr. Lyons stated that the thickness of oil shale overlying the coal was 3 ft., and of the coal 3 ft. This shale gave 23·7 gals. of oil per ton.

In Stewart's well there was also a scum of oil shale (yielding 25 gals. of oil per ton) about 1 ft. in thickness overlying coal, and similar occurrences have since been noticed for coal-seams met with in drilling for coal.

We find, therefore, that the fireclay roof of the coal has frequently become an absorber of oil in this series, which surely points to its being an oil-producing area.

During the sinking of diamond-drill holes the conclusion based on the shales in Lyons's and Stewart's wells was confirmed.

Most of the shales overlying coals in the diamond-drill holes of the Injune and Komine districts are oil shales. A large number were tested at the drill sites and a few typical samples were taken for analysis. These shales break up in a characteristic manner into small conchoidal fragments on drying, though the freshly mined shale has not the conchoidal fracture of torbanite.

The shales intercalated with coal-seams in No. 5 coal bore, Injune Creek, were carefully tested for oil in the field. True oil shales, mostly very low grade, but good evidence of the oil-bearing nature of the strata, were at 57 to 60 ft., 84 to 91 ft., 160 to 174 ft., 213 to 218 ft., 220 to 228 ft., 229 to 240 ft., 268 to 286 ft., 309 to

313 ft., 314 to 317 ft., mostly under calcareous bands and overlying coal. Between minor coal-seams 174 to 178 ft. oil shales were intercalated. Tar occurred in blue shale between 288 and 296 ft. and at 317 ft. The fireclay roofs of coal-seams appear to have exercised some catalytic action on migrating oil, and retained some of it in a polymerised condition.

Some samples of these oil shales have been further tested by the Government Analyst.

A sample from No. 4 diamond-drill hole (Barramundi Creek near Komine), 249 ft. 6 in. to 253 ft., gave—

Gallons of oil per ton	5·7
Shale oil in sample	2·6 %
Free oil in sample	0·14 %

Four other samples tested—331 G.S. No. 5 Bore 171 ft. to 173 ft. 6 in., 332 G.S. No. 5 Bore 177 to 178 ft. 2 in., 333 G.S. No. 5 Bore 234 ft., and 334 G.S. No. 3 Bore Injune—gave on distillation in the case of 331 and 334 a dark sticky oil amounting to a little less than one gallon per ton, and in the case of 332 and 333 to just over one gallon per ton. The samples also contained—

—	331.	332.	333.	334.
Asphaltene (soluble in chloroform)	0·04	0·12	0·04	0·03
Petroleum (soluble in petrol)	Nil	Nil	Nil	Nil

The occurrence of one foot of a black oil shale (torbanite) yielding 44·8 gallons of oil per ton, at the junction of Stewart's Creek and Bungeworgorai Creek near Orallo, in the Middle Walloon, has already been mentioned under Coals.

Migration of Oil in the Walloon.

The usual tendency is for oil to migrate up the dip of the beds in which it is contained and to lodge in anticlinal crests, domes, terraces, &c., or find an avenue of escape to the surface as a seepage.

Since the Lower Walloon is a formation which has produced oil as evidenced by the Roma oil gas, the occurrence of free oil in some of the oil shales of Injune Creek, and by the occurrence of inspissated petroleum in great thicknesses of shale in the same series, one would naturally look for oil-seeps where these rocks outcrop.

The absence of seeps is, however, easily accounted for. The oil was formed in the rocks in part during and in part prior to the Cretaceous, and since the Cretaceous lies conformably on the Walloon beds the uplift of the Dividing Range was subsequent to the period of oil production. The Dividing Range was uplifted at the end of the Marine Cretaceous (Rolling Downs) period. Long before this the oil had been produced and had migrated into suitable reservoir beds.

Would migration be upward or downward in a series of almost horizontal sediments, as these were prior to the folding? It should be remembered that these sediments were covered by the Cretaceous Sea. There were horizons of porous sandstone in the overlying Middle Walloon and Upper Walloon rocks, but they would have their interstitial spaces filled with water, the escape of which was hindered (*a*) by the impervious nature of the Lower Cretaceous sediments, (*b*) by the overlying Cretaceous Sea. The imprisoned water in the Upper and Middle Walloon rocks could not escape during the period of Cretaceous sedimentation. Below the Walloon rocks there were also horizons of porous sandstone and even coarse grits. In fact the Bundamba series gets coarser and coarser towards the base, and when readjustments take place between oil and water the forces of capillarity ensure that oil displaces water in the more porous beds, and water displaces oil in the finer strata. Moreover, the Bundamba beds had already undergone a certain amount of desiccation and were consequently not entirely waterlogged. This fact would, together with the coarse nature of the Bundamba grits, favour downward migration of the oil. The lenticularity of the Walloon strata would permit migration of the oil formed, by an alternation of lateral and downward passage, past the impervious shales to the porous sandstones below.

Once the oil reached the reservoir rocks it would move laterally up such dip as might exist. This was very slight, but in the Bundamba beds there was probably condensation of sediments around and on buried ridges yielding reflected anticlines in the Bundamba and Walloon. These reflected anticlines were subsequently covered with higher Walloon and Cretaceous strata. Buried ridges exist for reasons already given between Mount Hutton and Kilmorey, and between Eddystone Vale and Morven, and in numerous other places.

The whole oil series was subsequently folded in the period of uplift of the Dividing Range; in the elevated regions of erosion water making entrance into the porous beds would dam back the oil and prevent escape as seeps, whereas the whole of the synclinorial portions of the basin are effectively sealed both at the buried ridges and along the northern margin from Blackall to Diamantina Gates by later impervious sediments. The oil basin pinches out to the north along the belt lying between Blackall and Isisford against a huge unconformity between the Permo-Carboniferous and the Upper Walloon. In this region we get asphalt, ozocerite, and paraffin waxes recorded from bores.

It is quite possible that there may be some oil still held in porous sandstones in the Walloon Series itself. The Big Sandstone between the Lower and Middle Walloon would be the most favourable horizon, and would be near the 2,800-ft. depth in the Roma bore where Mr. Moore recently got petroleum indications.

Oil was recorded in 1912 as being present in the Warooby bore at 750 ft. This bore was sunk for water twenty chains north of the north-west corner of portion 153, parish Beaufort, Roma district, about eight miles north-north-east of Roma. The driller stated that the oil showed up most strongly when sandy strata were struck and floated away on water, smelling strongly at night. If this information is correct, as these seems every reason to believe, the sandy strata in the Upper Walloon have also trapped some oil, no doubt produced in the carbonaceous beds of the Upper Walloon itself. This bore was authorised to 1,500 ft. and being commenced in strata near the top of the Walloon would finish in the top of the Middle Walloon.

The Mount Basset bore, portion 225, parish of Beaufort, ten miles north-north-east of Roma, situated about four miles further north, gave the following section, pointing to Middle Walloon strata, from 1,600 ft. to the bottom, 1,743 ft., viz.:—

Ft.		Ft.	
1,604	to	1,609	Sandy shales
1,609	to	1,669	Sandy shales
1,669	to	1,673	Hard rock
1,673	to	1,679	Rough hard streak
1,679	to	1,681	Sandy shale
1,681	to	1,697	Brown shale
1,697	to	1,743	Brown shale.

Water stands at 225 ft. from the surface. The yield according to test is 17,000 gallons per day.

(d) The Character of the Waters in the [illegible]jon.

In the Upper and Middle Walloon formations the well and sub-artesian bore waters are fairly good fresh waters, but in the Lower Walloon formation the waters are very brackish or even salty. The Public Estates Improvement Branch of the Lands Department has kindly supplied me with copies of analyses of waters from their bores on Mount Hutton Estate, which are typical of the waters of certain strata in the Injune district:—

(1) *Bore 3A, Mount Hutton Soldier Settlement.*

Water from 505 ft.

Total solids	333·0 grs. per gal.
Sodium chloride	307·2 „
Alkalinity	14·3 per cent.
Sulphates, insoluble	6·0 „
Iron (Fe_2O_3) / Alumina (Al_2O_3)	6·0 „
Hardness	16·8 deg. Clark

(2) *Bore No. 1, Mount Hutton Estate (Gunnewin Town Bore).*

Water from 180 ft.

Total solids	627·8 grs. per gal.
Sodium chloride	618 „
Alkalinity	9·8 per cent.
Hardness	40 deg. Clark

(3) *Bore No. 8, Mount Hutton.*

Water from 140 ft.

Total solids	590·0 grs. per gal.
Sodium chloride	519·0 „
Calcium carbonate	38·0 per cent.
Hardness	15 deg. Clark

(4) *Bore No. 1, Mount Hutton, at Depth of 122 ft. in a 4 ft. 6 in. Coal Seam.*

Total solids	620·1 grs. per gal.
Sodium chloride	589·0 „
Calcium carbonate	10·8 per cent.
Hardness	24 deg. Clark

The gas recovered from the No. 34 Mount Hutton bore yielded—

	Per cent.
Carbon dioxide (CO_2)	1·1
Oxygen (O_2)	11·1
Methane (CH_4)	42·5
Nitrogen and inert gases	45·3
Total	100·0

The air present in the sample was 53·17. The air-free gas analyses:—

	Per cent.
Methane	90·6
Carbon dioxide	2·3
Nitrogen and inert gases	7·1
	100·0

During recent work in the Beaudesert district I collected samples of water in the Boonah district which came from permanent springs of a very briny nature. These were analysed by the Government Analyst and gave the following results:—

—	Salt Spring 1 m. N.E. of Kalbar.	Salt Spring near Coulson, por. 41, sub. 1, par. Dugandan.	Salt Spring, Hayes's Farm, por. 77, par. Dugandan.
	Grs. per gal.	Grs. per gal.	Grs. per gal.
Total solids	563·0	1,148·7	3,153·4
Sodium chloride	292·6	336·9	1,570·8
Magnesium chloride	180·9	215·8	281·3
Calcium chloride	60·3	559·0	112·8
Calcium carbonate	5·3	6·0	20·0
Calcium sulphate	20·4	30·5	159·7
Iron (Fe_2O_3) and Alumina (Al_2O_3)	trace	trace	1·8
Silica and insoluble	3·5	0·7	7·0

The Analyst adds that similar waters are very common all over Southern and Western Queensland. This statement is incorrect for two reasons: firstly the three waters are very different in nature, secondly saline waters are common only along certain belts, that is on certain formations in Southern and Western Queensland. The principal horizons for saline waters are (*a*) the Lower Walloon, (*b*) the Upper Bowen (Permo-Carboniferous), (*c*) the Upper part of the Cretaceous.

The investigations carried out by R. Van Mills and Roger C. Wells on the "Evaporation and Concentration of Waters Associated with Petroleum and Natural Gas," U.S.A. Geol. Surv. Bulletin 693, shows that the ratios of sodium to chlorine, magnesium to chlorine, and sulphate to chlorine are all smaller in oil and gas field waters than in ocean water, sulphate being comparatively absent in oil and gas field waters. In contrast to this, the ratio of calcium to chlorine is much greater in oilfields water than in ocean water.

In the three waters from Boonah district calcium chloride is remarkably high, especially in that from Coulson. Calcium chloride has not been estimated in the Mount Hutton waters, but as the sodium chloride content is very high there is not room in the analyses for excessive calcium chloride. Nevertheless the Hutton bore waters are of the type which may be regarded as oil waters. In some oilfields sulphur is a characteristic constituent of oil waters either as sulphuretted hydrogen, alkali sulphide, or sulphate formed by the oxidation of sulphides. In the Mount Hutton district the primary sulphur has been removed from the water and has been precipitated in the form of pyrites in the coals of the Lower Walloon Series and in the sandstones of the Basal Walloon.

Gas.

Gas occurs at a depth of over 3,600 ft. under Roma in strata corresponding to the Injune Creek measures, and in smaller amount in higher strata, as evidenced in the Lander Co.'s No. 1 bore, Orallo.

In two of the Injune water bores, Chapman's bore and Jennings's bore west of the .51-mile (bores 3 and 3A), gas was struck below 300 ft. This gas proved to be essentially methane. Gas has been struck in bores in the same horizon in the Brigalow, Warra, and Oakey districts.

The likelihood of oil being found in parts of the gassy horizon is very great, since the Injune bores show the rocks of this horizon to consist of rapidly alternating thin beds of various sedimentaries with frequent carbonaceous beds sandwiched in. The strata of this horizon are estuarine in nature and deltaic deposits in the Injune Creek belt. The country is somewhat saline, as already mentioned, but of positive indications there are none.

Oil Possibilities.

Of all the formations met with through the entire region, those outcropping in the Injune Creek basin show most freely the characters of an oil series, as regards nature of sediments and mode of deposition, as well as in the saline nature of this belt as compared with the other belts. We were informed by many cattle men that cattle do not require salt on the Mount Hutton (Injune Creek) runs, whereas both south and north of this belt salt is necessary. There were, however, no signs noticed either of oil exudations or of asphalt, bitumen, earthwax, or any other result of the evaporation of the liquid fractions of oil, on which one can definitely assert this area to be an oilfield. In the records of the water bores put down by the Public Estates Improvement Branch, which kindly supplied all the particulars they could, we see frequent reference to "oily shale" having been passed through. Some of the muds out of bore 3A, which were seen by the writer, were of a greasy nature, and floated as a dark dirty scum on top of the water; but as drilling was not in progress at the time to enable one to get an uncontaminated sample no analysis of these scums has yet been made. They are probably only carbonaceous muds. Several drillers consider that they noted a smell of kerosene in boring in various parts of the district, but such evidence is of little or no value. It would be much better if the drillers would make a practice of taking a sample of the drillings and forward them to the Mines Department for analysis, when they think they see indications of oil.

The apparent absence of earthwax, ozokerite, solid paraffin, &c., may be due to the Injune Creek beds being coal measures only in this region, but it is also quite possible that such substances will yet be found. Much of the country is covered with dense brigalow and belar scrubs. Brigalow is a timber which grows on heavy clays such as we get in association with coal-seams. It probably covers most of the outcrops of coal-seams, and if there were any oil or paraffin exudations in the district the odds are greatly in favour of their being hidden in brigalow scrubs. Discoveries may yet be made by the new settlers who are clearing and exploring their holdings. On the other hand there is a strong possibility that the Roma oil basin is a sealed basin—a possibility which will be discussed in a later section.

In drilling the Mount Hutton sub-bores, "hard streaks," "grey granite," and "cement" were recorded frequently by the drillers. These represent certain specially hard-cord beds in the calcareous series. Similar beds were struck in the bottom 500 ft. of the Roma bore, and such beds are often struck in oil bores.

Hard streaks were also met with in all of the diamond-drill holes. They are usually from 6 to 12 in. in thickness and consist of dense calcareous sandstone and shale. Some hard bands, however, were 8 to 10 ft. in thickness. A typical sample of a

hard band from diamond-drill No. 2 bore 66 ft. was sent to the Government Analyst for analysis. His return gave—

	Per cent.
Moisture	0·7
Loss on ignition	31·5
Silica	20·4
Alumina	8·3
Ferric oxide	2·8
Lime (CaO)	34·8
Magnesia (MgO)	0·5
Manganese oxide	0·1
Difference (alkalies)	0·9
Total	100·0

The entire calcareous area of Mount Hutton is remarkably saline. Cattle we are told will not lick rocksalt; saltbush of certain species grows there; and certain white efflorescences were seen in several places on Oakey Creek and elsewhere. These tasted distinctly of salt. Salinity being a characteristic of oil country this may be taken as a favourable sign.

We were told that the water in several of the Injune wells smelt strongly of petroleum. This was, however, not confirmed.

The calcareous strata around Injune Creek contain occasional red ironstone beds. Red beds may be formed by the dehydrating action of salt solutions (Bull. 693, U.S.A. Geol. Sur.). In the calcareous strata we also find fissures with cone-in-cone limestone as on Durham Downs, and joints with cone-in-cone limestone which are very common throughout; and the limestones interbedded with the shales and calcareous sandstones are magnesian. In the escape of oil gas, salt often escapes with the gas, and to a certain extent also carbonate and sulphate of lime. Hence the origin of the salt domes of Texas and their associated gypsum contents. In oil and gas wells carbonate of lime containing salt frequently causes clogging up. The cone-in-cone limestones are probably formed during and after the expulsion of gas. Mixing of surface waters with deep-sea brines causes clogging with lime, thus—

$$2\,NaHCo_3 + CaCl_2 = 2\,NaCl + CaCO_3 + CO_2 + H_2O.$$

In an oil series cementation processes take place, causing the magnesia in the impounded water to react with carbonate of lime, yielding dolomitic limestone and calcium chloride. Waters containing magnesium chloride also act on calcium silicate, forming magnesium silicate, and calcium chloride magnesium is therefore first eliminated and precipitated. Some of the chloride of lime in the oil is turned into bicarbonate by sodium bicarbonate. This portion of the lime may escape with gas into fissures and be precipitated as cone-in-cone limestone. Some of the lime in the solution as bicarbonate may be forced into overlying clay strata when the permutite reaction takes place, the lime entering into

the form of lime aluminium silicate (the drillers' "hard streaks" and "grey granite"), and the soda is carbonated. A further invasion of salt (NaCl) water might regenerate CaCl and change the lime felspar into the even harder soda felspar or felspathoid, thus—

$$Na_2Al_2Si_2O_8 + Ca(HO_3)_2 = CaAl_2Si_2O_8 + 2NaHCO_3$$
$$CaAl_2Si_2O_8 + 2NaCl = Na_2Al_2Si_2O_8 + CaCl_2.$$

The hard streak and the cone-in-cone lime veins, the red beds, and the undulating folding of the beds due to chemical change in the Lower Walloon, are all features likely to have been derived through the chemical changes accompanying the migration of oil waters.

Since oil is more stable at lower temperature and pressure, and gas forms at high temperature and pressure, it would be advisable to sink for oil near Orallo, where the Roma gas zone would be, but at a depth of less than 2,000 ft.

It will be noticed, in studying the sections of the Injune Creek water bores, that the strata are characterised by rapid alternations, by "hard shells," and such characterises an area favourable for oil. The calcareous series of the Walloon is remarkably deficient in well-preserved fossil remains, especially the limestones and sandy limestones, which weather with a yellow surface. The sandstones (calcareous) sometimes contain obscure casts of fossil leaves and stems generally as a spongy silicious material, formed in hollows left by the complete removal of the organic matter.

It is therefore very probable that oil reservoirs may be found in or below these strata. Another feature pointing that way is the occurrence of a series of porcellanite shales between the 45-mile and the 47-mile on the Injune Creek line, best developed near the 47-mile. This is a feature reminding one of Trinidad, where such shales represent a transition between the petroliferous and carbonaceous phases (Cunningham Craig).

VI.—THE ARTESIAN WATER IN THE WALLOON.

The Roma water bore draws its supplies from the Upper Walloon, at a depth of about 1,300 ft. If this can be really regarded as the main source of artesian water, the main intake would be, not the Blythesdale Braystone (so called), but the sandstone series overlying the Cornwall coals. A sub-artesian bore at Orallo draws on this stratum and yields a very fine supply of excellent water.

The old Mitchell town bore, like the Roma bore, passed through coal-seams and reached a depth of 1,405 ft., drew its main supplies from the 1,270-ft. stratum, and yielded 205,000 gallons per day, approximately the same as the Roma bore. In all probability it taps the same horizon. This bore has since been

deepened to nearly 4,000 ft. and has passed through the Middle Walloon coals, and now yields about half-a-million gallons per diem. These bores then tap the Upper Walloon.

The Charleville town bore reached a depth of 1,371 ft., drew its main supply from 1,310 ft., and yielded 3,000,000 gallons of water per diem.

According to Mineral Index, coal occurs at Burrandilla thirty miles south-west of Charleville. This analysed :—

Moisture, 2·7; volatile hydrocarbon, 40·1; fixed carbon, 42·1; ash, 15·1.

The analysis is that of a typical Walloon coal of the Cornwall type.

Particulars of this coal are not available, but it probably came out of a bore-hole. Some idea of the structure of the country in this region can be got from the following section of Burrandilla bore No. 2 (lat. 26° 18′ 22″, long. 145° 42′ 50″) :—

Surface to 151 ft.	..	Clay	
151 ft. to 1,905 ft.	..	Black and blue shales (Cretaceous Marine)	
1,905 ft. to 1,954 ft.	..	Grey sandy shale	Upper Walloon
1,954 ft. to 1,987 ft.	..	Chocolate shale and grey shale	
1,987 ft. to 2,067 ft.	..	Chocolate and brown shale	
2,067 ft. to 2,111 ft.	..	Chocolate and grey shale	
2,111 ft. to 2,202 ft.	..	Brown and black shale	
2,202 ft. to 2,257 ft.	..	Sandy shale and sandstone	
2,257 ft. to 2,342 ft.	..	Hard sandstone and pipeclay	
2,342 ft. to 2,591 ft.	..	Chocolate shale	
2,591 ft. to 2,549 ft.	..	Chocolate and brown shale	
2,549 ft. to bottom	..	Grey shale and pipeclay	

The Koreelah bore on the same station finished at 2,518 ft. in black sand and charcoal (?).

Obviously at Charleville and on Burrandilla holding the artesian water is drawn from the Walloon formations, Upper and Middle.

On Bulburrum holding, north of Charleville, a 4-ft. coal-seam was pierced in a well at 60 ft.

There must be a roll in the strata which brings the Walloon Series closer to the surface again on a north-south line joining the Enniskillen Range with Charleville. Charleville is thus on a roll which separates the south-eastern artesian basin from the northern. Both basins are supplied mainly from the Upper and Middle Walloon.

As to evidence of the origin of artesian water we have two conflicting facts to note :—

(1) We were camped on Frankvale Creek while 3 in. of rain fell in less than two days, and nearly 2 in. in a night. The creek was only running a trickle after all this. Seemingly most of the rain was quickly absorbed in the porous, calcareous sandstones of this area, equivalent to the sandstone series forty-seven to fifty-one miles from Orallo on the Injune line. This favours the meteoric hypothesis.

(2) We inspected mound springs on Mount Hutton and saw the Timor Spring flowing freely out of Upper Bundamba sandstone. These are similar to springs in the north-west corner of the Pilliga Scrub in New South Wales in similar sandstone. The latter springs ceased to flow when the bores of New South Wales became numerous. This fact favours the plutonic theory. It is quite possible that the Bundamba horizon is fed by plutonic and one or more of the higher horizons partly by meteoric water.

It is of highest importance, both from the economic and scientific viewpoint, that diamond-drill holes should be sunk across our Western country at 30-mile intervals to a depth of 3,000 ft., to give us a true east-west and north-south section of the artesian basin. Of course true bedrock would only be reached in the bores near the margin.

The Crystalbrook surface sandstones have the massive weather-resisting facies of the Bundamba formations but may be largely of Basal Walloon age. They seem to dip definitely under the Toolumbilla group of calcareous shales, which have been correlated with the Injune Creek series. I am indebted to H. R. Loughman, Esq., for particulars of bores sunk on Crystalbrook Station. In all of these good sub-artesian supplies were struck.

The following are the particulars supplied by Mr. Loughman:—

No. 1 Bore, Doyle's Gully—

Sandrock to 50 ft.

50 ft. to 190 ft., layers of white clay, sandstone, and shale (water at 150 ft.).

190 ft. to 236 ft., cloddy brown shale.

236 ft. to 260 ft., layers of sandrock, sand, and one thin coal-seam (water rose in bore at 260 ft.).

260 ft. to 280 ft., "river" sand.

No. 2 Bore, Lagoon Gully—

Sandstone to 90 ft. (fresh soakage at 92 ft.).

92 ft. to 137 ft., layers of dark shale, sandstone, and sandy clay.

137 ft. to 202 ft., hard grey shale.

202 ft. to 242 ft., layers of sandrock, shale, sandy clay, and traces of coal.
242 ft. to 319 ft., layers of brown shale and white clay.
319 ft. to 370 ft., coarse white sandstone.
370 ft. to 380 ft., white clay (water rose to 25 ft. from surface.
380 ft. to 410 ft., hard brown shale.

No. 3 Bore, Pine Camp Gully—
6 to 50 ft., clay and shale.
50 ft. to 80 ft., hard black shale.
80 ft. to 179 ft., white clay and sandstone.
179 ft. to 269 ft., hard glassy sandrock.
269 ft. to 306 ft., grey clay (water rose in bore).
306 ft. to 370 ft., glassy sandrock.
370 ft. to 385 ft., white clay.

No. 4 Bore, Emu Gully—
Sandrock to 94 ft.
94 ft. to 156 ft., black shale.
156 ft. to 264 ft., sandrock, occasional shale layer.
264 ft. to 303 ft., hard black shale.
303 ft. to 339 ft., hard brown shale.
339 ft. to 370 ft., chocolate mud and sandrock.
370 ft. to 428 ft., alternate layers of sandrock or brown shale.

The above bore sections show rather more shale than is usual in the Bundamba sandstones, and the occurrence of thin coal-seams is also suggestive of a Basal Walloon age for the Crystalbrook formations, yet both shale-beds and thin coal-seams do occur in the Bundamba Series, and the lithological character of the sandstone (silicious and not felspathic) points to a Bundamba age.

D. Penhallurick, Esq., the owner of Toolumbilla Station, also kindly supplied me with bore data from his run. He states in a letter to one of us that he is satisfied that plentiful water supplies can be obtained at a depth of 800 ft. on any part of his run.

No. 1 Bore, 800 ft. in depth—
At 40 ft. driftsand and water, blue shale at 90 ft., and a small coal-seam came in at 170 ft., more blue shale to 700 ft., where driftsand again came in, then sandstone to the bottom.

No. 2 Bore, 434 ft. in depth—
Blue shale met with at 70 ft. At 140 ft. a small coal-seam came in in the blue shale, sand-drift at 380 ft., and at 410 ft. water was struck in sandstone which continued to the bottom.

No. 3 Bore, 800 ft. in depth—

Driftsand from surface to 100 ft., then blue shale at 140 ft. continuing to 700 ft., where driftsand came in and sandstone to the bottom.

It is interesting to note how both the Calcareous Marine Cretaceous and the Calcareous Walloon are described as blue shale by the driller. The Toolumbilla bores seem to have been commenced in the top measures of the Calcareous Walloon (sand-drift) and have passed through the Calcareous Walloon in 700 ft., reaching water in the top of the Basal Walloon sandstones. It will be noticed on the Roma-Moolayamber section (fig. 1) that the lower shaly group on Calcareous Walloon is also about 700 ft. in thickness in that region. Apparently the Calcareous Walloon carries much less coal in the Toolumbilla area than in the Injune area, and it is quite possible that the 700 ft. passed through in Nos. 1 and 3 bores represent both the upper and lower members of the Calcareous Walloon, which together attain a thickness (estimated) of 1,400 ft. in the Injune area.

VII.—THE BUNDAMBA FORMATION.

This formation was found to extend from Mount Hutton head station near the junction of Hutton and Injune Creeks across to the Carnarvon Range, and to cover almost the whole of Westgrove Station, Timor, Huttonvale, and other smaller properties on the east side of the divide; while west of the divide it extends over Merivale, Crystalbrook, and Mount Eddystone Stations.

The sandstones are dominantly silicious sandstones with caliphobe vegetation. They are overlain by a conglomerate which is the transition stage to the Basal Walloon, and underlain by a much bigger conglomerate which forms the passage bed to the Ipswich Series. They contain some intercalated aluminous and silicious shales.

The upper strata of the Bundamba contain water beds which give out spring water at Mount Hutton head station, Timor, Crystalbrook, Mount Owen, &c., while good sub-artesian supplies have been tapped on Sardine Creek and a flowing spring occurs at the head of the Dawson River north-north-west of Boxvale, both in the lower beds of the Bundamba.

It is highly probable that deep bores on Forest Vale would tap good supplies of true artesian water in the Bundamba at a depth of 4,000 ft. unless granite and metamorphic rocks should be met with at higher levels. The possibility of the latter contingency is indicated by the occurrence of serpentine and asbestos near Mount Owen, of granite at the head of the Warrego, and of palæozoic schists at a depth of 2,485 ft. in the Morven town bore.

The top of the Bundamba is dipping south-west at 7 deg. near Hutton head station, roughly the same where the Westgrove road crosses Hutton Creek. About halfway between Hutton Creek and Baffle Creek, on the Boxvale track near Laycock's, a west-south-west dip at 10 deg. showed clearly, and a small seeming overthrust fault showed in the sandstone with a west-south-west dip at 20 deg. The divide between these two creeks approaches close to Baffle Creek and reaches an altitude of 1,650 ft. In Baffle Creek the dip was west to north-west at 10 deg. in some places, while in others the rocks seemed to lie horizontal. On the Dawson River east of Boxvale the bulk of the sandstones lay practically horizontal, but in places west, west-south-west, and west-north-west dips at low angles were seen. On Jack's Mountain, about five miles east-north-east of Boxvale, we get most variable dips. Seemingly a number of strong parallel faults have developed here in the sandstone, and the blocks between them have been tilted by differential earth movements.

About a mile and a-half west of Jack's Mountain a steady west-north-west dip at low angles is seen, while the eastern flank of Jack's Mountain consists of sandstone dipping west. A strong uplift in the region occupied by the Basin and the Arcadia Valley has probably allowed stream action to work into the soft Ipswich strata under the Bundamba, and thus led to the carving out of canyon topography and gorge scenery equal to the finest in the Blue Mountains. West of Jack's Mountain occurs a semi-lunar belt of brigalow scrub, one wing of which lies between Harding Creek and Jack's Creek. The soil and vegetation here are not of the Bundamba type. It resembles Walloon or Ipswich in this respect, but we are inclined to think, by virtue of its position, that in reality it represents a calcareous horizon within the Bundamba Series itself.

About five miles south-east of Boxvale occurs an outcrop of aluminous shales. Another outcrop of porcelaneous-aluminous shales occurred about two miles south of Jack's Mountain. These shales appear to be interbedded in sandstone of the Bundamba type, and are not, as far as we could ascertain, fossiliferous. A small band of conglomerate overlies this shale horizon. From Boxvale north to the Carnarvon Range sandstones were the paramount formation. After crossing the Dawson north of Boxvale, we followed the Wallaroo Creek gorge, with sandstone escarpments on both sides until the head branches of Wallaroo Creek are reached. These come together in an open plain consisting of red pebbly soil, which was subsequently seen to be identical with that shed by the uppermost Ipswich strata. A low watershed was crossed and the head waters of Spring Creek were followed down on similar soil. Ipswich fossils were obtained some miles down Spring Creek, where the track passes between several sandstone mesas which yielded the attached section.

The altitude here is about 1,450 ft. at the base of the hills which rise 200 ft. higher. We now turned north-west and followed the base of the Bundamba to the divide between Spring Creek and Moolayamber Creek. Here the sandstone mesas on the divide have been very much less disturbed in the area shown in our line of section which was followed on the return journey. Here they seem to have an average gentle south-west dip, and, if the southerly factor of that dip is 1 in 100 as in the Walloon, the Bundamba strata have a thickness of 3,000 ft. as against 5,000 ft. of Walloon strata. The general indications, however, point to the Bundamba area as a whole dipping more steeply than the Walloon, especially the zone between Baffle Creek and Hutton Creek. Hence the total thickness of the series may considerably exceed the above estimate.

The sandstones outcropping on Mount Byan Byan, Mount Kennedy, and on Kilmorey are remarkably like the Bundambas in lithological characters, vegetation, and physiographic features. Nevertheless, they cannot be Bundamba formation without assuming either a huge east-west fault or an enormous unconformity in the latitude of Wahroonga, and there is absolutely no field evidence to support such a theory. These sandstones must therefore be regarded tentatively to be the equivalent of the Big Sandstone below the Orallo measures.

In the Upper Maranoa district there are patches of sandstone which may belong to the Upper Cretaceous, but the dominant sandstones are on present evidence Bundamba the same as those of Westgrove. The dip is gently to the south-west. By closely observing a tesselated sand ironstone bed between Simpson Creek and Eddystone Vale, a dip to the south-west with the southerly and westerly components each about 60 ft. in the mile was determined.

A very interesting feature at Crystalbrook is the mound spring which was visited and described by Mr. L. C. Ball, B.E., in Q.M. Journal No. 1918, pp. 508, 509. Mr. Ball describes the occurrence at considerable length, and quotes analyses of the peaty substance of the mound as supplied by the Government Analyst's department.

The principal mound spring is only a few hundred yards north of the Crystalbrook homestead. It was originally a large peat swamp with a spring near the top end. The mound closely resembled the mounds on Timor and Mount Hutton Stations and is undoubtedly of the same origin—that is, the bountiful water supply round the spring has led to an enormous growth of vegetation, and thus a thick mantle of peat was formed which gradually grew into a mound.

Several smaller mounds occur in the vicinity, and there are also springs in the banks of the creek half-a-mile above the homestead. In each of these cases sulphur is deposited in the peaty muds.

The main peat mound took fire a few years ago and burned for nine months. Since the fire the spring has partly dried up.

Both in the peat mounds where the spring water stands and in the banks of the creek where spring water soaks down over the rocks, one can see a black tarry-looking slime forming thick encrustations in places. This slime dried will fuse with intumescence, then it burns with a blue flame emitting an odour of burning sulphur, and leaves a yellow spongy cinder. A sample of this slimé from the spring in the main creek was scraped off the rocks and was submitted to the Government Analyst. The result was as follows:—

Total hydrocarbons	Nil
Total sulphur	12·1 per cent.

The spring-water sample from Crystalbrook, analysed for Mr. Ball in 1918, contained sulphates and traces of sulphuretted hydrogen. The slime referred to above is undoubtedly a bacterial slime, and probably the sulphur in the deposit is formed wholly by the action of sulphur producing bacteria on sulphuretted hydrogen water. The bacteria are aerobic and oxidise H_2S to sulphur dioxide. Then the reaction $H_2S + 2SO_2 = H_2SO_4 + 2S$ takes place, and the sulphuric acid is immediately seized by the alkalies in the water to form sulphates.

The source of the sulphuretted hydrogen may be either due to the fixation of carbon in the hydrocarbons of gassy coal, and the combination of the liberated hydrogen with the sulphur of the coals, or due to the liberation of sulphide of hydrogen from basaltic lavas at a depth.

The sub-artesian bores at Crystalbrook have already been discussed. One of them, the Doyle Gully bore, eight miles south of Crystalbrook, is truly artesian, the water flowing over the casing. The elevation of the country here is, however, only about 1,500 ft. above sea-level, while the other bores west and north of Crystalbrook commence at least 200 ft. higher.

The escape of water from the Upper Bundambas at the outcrop north of the boundary between the Basal Walloon and Bundamba is a very constant feature of these beds. Springs abound on Eddystone Vale (Mount Owen), Crystalbrook, Merivale, Timor, Mount Hutton, &c., and many of them are mound springs. The water is fresh, and usually accompanied by some escaping gas. As will be seen later, similar springs occur in the same formation on the Dawson River. It is highly probable that gas pressure is the driving force behind these waters. The phenomenon has probably an important bearing on the oil problem.

VIII.—THE IPSWICH.

The Ipswich beds were first seen unmistakably at the head of Spring Creek (altitude 1,450 ft.) where we obtained *Thinnfeldia odontopteriodes* in brown shale and an abundance of Equisetites, Neocalamites, and Schizoneura in a spheroidally weathering limestone quite similar in nature to that which occurs in the Lower Walloon at Lighthouse Hill, Durham Downs, Myall Creek, and Injune Creek. The character of the last Ipswich shales and the earliest Walloon shales was therefore the same, though between 3,000 and 4,000 ft. of sandstone separates them. From similarity of soil it was possible also to include the head water of Wallaroo Creek in the Ipswich. It seems, therefore, that the gap on the Carnarvon Range is Ipswich formation capped with mesas of Bundamba. The same was the case with the spur between Spring Creek and Moolayamber Creek. The limestones in the base of the mesas grade upwards into shales, then tuffy calcareous shales, and finally we get a thin bed of white and a bed of red shale, over which a bed of coarse conglomerate comes in. This is succeeded by sandstones, which, however, are seen to be largely felspathic and somewhat calcareous in the lower beds. (Fig. 11.)

Fig. 11.—Typical Section at Spring Creek in Carnarvon Range.

In Bullaroo Creek, where we camped at an altitude of 1,250 ft., the rocks were shales all dipped uniformly south at 10 deg. About two miles below our camp sandstones underlie the shales. The shales are calcareous and carry abundant fossil remains in which *Thinnfeldia odontopteroides* is abundant. As the creek is followed up to its source in a southerly direction we noticed that the same calcareous shales continued to 1,580 ft. Then calcareous spheroidally weathering blue-black shales, tuffy blue-black sandstones, and limestones alternated. At 1,600 ft. a south-west dip at 17 deg. was noticed, but it is presumed that the ground must have been disturbed here—tuffy calcareous sandstone ensued to 1,700 ft. This level was that of the gaps on the range, and conglomerate débris is scattered on this level. From

the thickness of the tuffy strata observed at the head of Bullaroo Creek compared with the thickness of these at the head of Spring Creek, it is obvious that this tuffy calcareous series is of uneven thickness. The sandstone mesas at the head of Bullaroo Creek rise perhaps 500 ft. higher than the divide—i.e., to 2,200 ft.

From our camp on Bullaroo Creek an ascent was made to the foot of the sandstone cliffs to the west. The section was practically the same as observed elsewhere, but the white and chocolate Thinnfeldia shales, which underlie the conglomerate, showed here, while at the head of Bullaroo Creek they are obscured in rock-waste.

In all, we saw in this section 450 ft. of Ipswich strata consisting wholly of calcareous shales and limestones and tuffy shales, excepting perhaps 20 ft. at the top which would be made up of chocolate and white Thinnfeldia shale and conglomerate. This series was distinctly seen to overlie sandstone, but we did not follow the creek down to the Moolayamber Creek junction and study the lower beds. There is no coal in this calcareous series.

Weathering of the tuffy members at the top of the series often gives rise to chocolate-coloured soil and rock exposures, suggesting the Narrabeen shales of New South Wales. Like the latter they are tuffy, but the sediments in the tuffy beds are more calcareous here than in the Narrabeen series.

We have in the general sculpture of the canyons of Arcadia Creek, Moolayamber Creek, and the head waters of the Dawson a scenic type developed which is an exact parallel to the Hawkesbury sandstone scenery in New South Wales in the Blue Mountains.

We have a series of tuffy shales below these sandstones which in part weather like the chocolate shales of the Narrabeen series, and which like the Narrabeen series are full of Equisetite remains.

A study of this region is highly suggestive that the Bundamba is the equivalent of the Hawkesbury, and the Ipswich of the Narrabeen series.

The mound springs in the top of the Bundamba near Mount Hutton and Timor are a link between these rocks and the "intake" (supposed) in the north of the Pilliga Scrub in New South Wales, where similar mound springs existed, but gave out when many bores were sunk to the west.

Information was received from several stockmen to the effect that the Coorada country and other country west of Coorada, in that large area marked "Gympie" in the portion of district Leichhardt, is ironstone gravel country and redsoil country, similar to that observed by us at Spring Creek. The Rolleston country was described as being similar too in vegetation, soil, &c., and also in rocks as far as a bushman can judge. One may

deduce from this, and from the fact that the Upper Bowen and Ipswich are composed of similar beds, that no Gympie rocks exist in this area, and also that the Upper Bowen and the Ipswich Series are likely to be confused. If that is so the two series are quite likely to be conformable with one another.

Such an occurrence would give us a complete conformable series from Lower Bowen around Banana to Tertiary at Winton, with, of course, unconformities in places.

Warrong Station at the head of the Maranoa is, according to reliable information received, composed of sandstone similar to Crystalbrook, but the top of Warrong and Mount Moffatt outstation is large shale country in the ravines—the shales underlying sandstone cliffs—and this country is forested with spotted gum and zamia similar to the Carnarvon Range north of Boxvale on the Moolayamber side. It is therefore undoubtedly Ipswich formation.

It is interesting to note that near Eddystone Vale, about six miles up the Maranoa from the head station, occurs an outcrop of asbestos-bearing rock, probably serpentine, surrounded by sandstone. This must be an old pinnacle of metamorphics. On reliable information we have ascertained that there is an outcrop of granite with quartz-veins similarly situated at the head of the Warrego. These facts show that Permo-Carboniferous and Mesozoic sediments in this region were deposited on a highly dissected land surface, a fact pointing to block-faulting ushering in the Permo-Carboniferous (Lower Bowen) and possibly other periods.

At Kilmorey fragments of pegmatite were found amongst other volcanic ejacamenta, proving that granite rocks existing in the lower regions of the basaltic neck escaped sedimentation between Kilmorey and the Warrego until Bundamba times.

IX.—CONCLUSIONS.

Certain problems were stated in the early part of this report to have arisen out of the work. The conclusions on these, from the observations made in the section so far dealt with, are as follows:—

1. The Walloon belt is nearly sixty miles wide from the Cretaceous boundary to the Bundamba boundary, and the series is 5,000 ft. in thickness. The Bundamba belt is about twenty-five or thirty miles wide, and is 3,000 ft. roughly in thickness.

2. The general dip of the whole series is south-south-west until the north-south segment of the Dividing Range is approached. This range is of fold origin, subsequently faulted with a downthrow to the west. Dips are generally south-east east of the range, and west to south-west west of the range.

3. The general section agrees well with the strata met with in the Roma bore. The Roma water bore draws its supplies from the Upper Walloon. The oil zone is just above the Injune Creek coal measures in the top of the Lower Walloon.

4. The data for estimating the thickness of the Walloon and Bundamba are given in the text.

5. The area south of Kilmorey where the anticline of the north-south segment of the Dividing Range sinks under the plains is an area which should be tested for oil. So should also the district between Orallo and Cornwall.

6. For reasons already given it is considered that artesian water occurs in many series: in the Upper Walloon, the Middle Walloon, the Basal Walloon, and the Bundamba. Until we know definitely from what stratum or strata a bore draws its supplies, geological conclusions based on isopotentials are apt to lead to confusion of thought.

7. The Walloon coals met with are on the whole inferior and in bad standing ground and also in sub-artesian country; but there are several good seams (3 ft. and over) of good-quality Walloon coal at shallow depths in what appears excellent standing country at Injune Creek.

Altogether field evidence and boring records prove the existence of numerous seams both in the Cornwall-Alcurah series and in the Injune series.

8. From the nature of the pebbles and boulders in the supposed glacial heaps around the old Hutton Station, it is concluded that the icebergs came from the north or north-east, perhaps from the old Anakie Ranges or the Auburn Range. Consequently this would have been very high land in the end of the Cretaceous.

9. The only volcanic rocks met with were basalts probably of Miocene age. They have flowed out at intervals all along the north-south portion of the Dividing Range east of the Maranoa, and also at Springsure and on the same north-south line north of Springsure to Clermont. Along the whole of this volcanic line the geological map of Queensland points to heavy faulting.

10. The gorge scenery at the head of the Dawson has developed by the same processes and in the same geological time as the Blue Mountains in New South Wales.

11. The fossils collected and mentioned in this section are satisfactory evidence of the geological boundaries shown on this map.

12. A large area shown on the old geological map as "Gympie" will have to come out, consisting of Ipswich strata with Bundamba cappings.

APPENDIX I.

FOSSIL PLANTS OF IPSWICH AND WALLOON AGE, COLLECTED BY DR. JENSEN TO THE NORTH OF ROMA AND EXAMINED BY THE LATE MR. W. T. WILLCOX.

No. and Species.	Locality.	Horizon.	Matrix.
2. Thinnfeldia sp. ..	Bullaroo Creek, 5 miles below Moolayamber Pass	Ipswich (Middle)..	Yellow fine micaceous sandstone
33. *T. odontopteroides* ..	Buckland Creek, 12-15 miles above Nardoo	do. ..	do.
3. Do.	Spring Creek, above Moolayamber Gap	Ipswich (Upper) ..	Brown tuffy sandstone
4. Do.	Bullaroo Gorge, in creek	Ipswich (sp. fallen from top of series)	Pink hard shale
9. Thinnfeldia fragment	Spring Creek, near Moolayamber Gap	Ipswich (Upper) ..	Red shales
5. Gymnospermous seeds	Bullaroo Gorge ..	do. ..	Pink shale and hard
6. Equisetites stems ..	do. ..	Ipswich (Middle)..	Yellow fine micaceous sandstone
10. Do.	Spring Creek, near Moolayamber Gap	Ipswich (Upper) ..	In grey limy sandstone
11. Do.	Conglomerate Hill, Alcurah, W. of Orallo	Walloon (Middle)	In red ironstone
24. Do.	5 miles S. of Durham Downs	Walloon (Lower)..	do.
26. Do.	Lighthouse Mtn., Durham Downs	do. ..	In calcareous grey mudstone
27. Do.	Shanahan's Farm, 25 miles N.N.E. of Roma	Walloon (Middle)	In limonitic sandstone
31. *Equisetites rotiferum* (diaphragm)	Jerry's Crossing, Forest Vale, 40 miles N. of Mitchell	Walloon (Middle)	In blue shale
33. Equisetites stems ..	Buckland Creek, 12-15 miles from Nardoo	Ipswich (Middle)..	In yellow mica sandstone
10. Schizoneura ..	Spring Creek ..	*Vide* above.	
34. Do.	Bedourie and Wallangara Creek	Ipswich (Upper) ..	In calcareous grey mudstone
7. *Neocalamites Carrerii*	Bullaroo Gorge, 5 miles below Moolayamber Pass	Ipswich (Middle)..	In yellow mica sandstone
8. *N. horensis* ..	Bullaroo Gorge, 5 miles belowMoolayamber Pass	do. ..	In yellow mica sandstone
22. Neocalamites sp. leaves	Conglomerate Hill, Alcurah, 6 miles N.W. of Cornwall Station, Orallo district	Middle Walloon ..	Red ironstone
23. Do.	49½-mile, Injune Railway.	do. ..	do.
19. Do.	Lighthouse, Durham Downs, 60 miles N.N.E. of Roma	Lower Walloon ..	Grey calcareous mudstone
15. Gymnospermous seeds	49½-mile, Injune Line	Middle Walloon ..	Red ironstone
26. Do.	Lighthouse, Durham	Lower Walloon ..	do.
31. Gymnospermous fern seeds	Jerry's Crossing, 40 miles N. of Mitchell	Middle Walloon ..	Blue shale
1. *Sphenopteris* sp. prob. *superba*	Well 3 miles E. of Forest Vale, 40 miles N. of Mitchell	do. ..	Shale
23. *S. superba* ..	Alcurah Creek, Cornwall, Orallo District	do. ..	Red ironstone

APPENDIX I.—*continued.*

No. and Species.	Locality.	Horizon.	Matrix.
29. *S. superba* ..	Ferguson's well near 58-mile, Injune Railway	Lower Walloon ..	Blue shale to dark grey
30. Do. ..			
31. Do.	Jerry's Crossing, Forest Vale, 40 miles N. of Mitchell	Middle Walloon ..	Blue shale
11. *Cladophlebis australis*	Conglomerate Hill, Alcurah Creek, Cornwall Station, Orallo District	do. ..	Red ironstone
14. Do.	do.	do. ..	do.
17. Do.	49½-mile, Injune Railway	do. ..	do.
25. Do.	46-mile, Injune Railway	do. ..	do.
21. Do.	5 miles S. of Durham Downs	Lower Walloon ..	do.
24. Do.	do.	do. ..	do.
28. Do.	Shanahan's farm, 25 miles N.N.E. of Roma	Middle Walloon ..	Yellow limonitic sandstone
32. Do.	3½ miles S. of Toolumbilla, 60 miles N. of Mitchell	Lower Walloon ..	Red ironstone
16. *Tæniopteris spathulata*	49-mile, Injune Railway	Middle Walloon ..	do.
12. Do.	Junction Alcurah and Bungeworgoral Creeks	do. ..	do.
19. Do.	Lighthouse Hill, Durham Downs	Lower Walloon ..	Grey limy mudstone
27. Do.	Shanahan's, 25 miles N.N.E. of Roma	Middle Walloon ..	Yellow limonitic sandstone
32. Do.	3½ miles S. of Toolumbilla	Lower Walloon ..	Red ironstone
32. *Otozamites Feistmanteli*	do.	do. ..	do.
16. Ginkgo sp.	49-mile, Injune Railway	Middle Walloon ..	do.
31. *Ptilophyllum pecten*	Jerry's Crossing, Maranoa River	do. ..	Blue shale
13. *Dictyophyllum Davidi*	Junction of Alcurah and Bungeworgoral Creeks	do ..	Red ironstone
14. *Brachyphyllum crassum*	Diamond-drill coal bores, Komine and other places in Injune Creek district	Lower Walloon ..	Black shale

APPENDIX II.

LIST OF CRETACEOUS MARINE FOSSILS COLLECTED BY DR. JENSEN AND DETERMINED BY THE LATE MR. W. T. WILLCOX.

Species.	Locality.	Horizon.	Matrix.
Worm tracks	Taboonbay Creek, near old hotel site	Basal-bed of Marine	Sandstone, Blythesdale in part
Maccoyella Barclayi ..	Taboonbay Creek, 2-3 miles E. of old hotel site	Near basal bed of Marine	Limestone overlying worm-track sandstone
Small gasteropods undetermined	do.	do.	do.
Belemnites sp. ..	do.	do.	do.
Fish vertebra ..	do.	do.	do.
Glycimeris sp. ..	do.	do.	do.
Pseudomaura variabilis	do.	do.	do.
Petrified wood ..	do.	do.	do.
Glycimeris sulcata ? ..	2 miles S. of Minka-Orallo road	Near base of Marine, same horizon as Taboonbay fossils	Limy mudstone to limestone
Glycimeris Maccoyi ?	do.	do.	do.
Fissilunula Clarkii ? ..	do.	do.	do.
Fissilunula Clarkii ..	Selection 268, par. Baranbanbal	Basal beds of Marine, almost same horizon as above	Limestone
Maccoyella reflecta ..	do.	do.	do.
Maccoyella Barclayi ..	do.	do.	do.
Merismopteria macroptera	do.	do.	do.
Malletia elongata ..	do.	do.	do.
Glycimeris sulcata ..	do.	do.	do.
Glycimeris sp. ..	do.	do.	do.
Inoceramus Etheridgei	do.	do.	do.
Pseudomaura variabilis	do.	do.	do.
Palæomæra sp. ..	Selection 268, par. Baranbanbal	Basal beds of Marine, almost same horizon as above	Limestone
Coral sp.	do.	do.	do.
Belemnites sp. ..	Bungeworgoral Creek, near Hodgson	Higher horizon than the above	Calcareous shales
Maccoyella corbiensis ..	do.	do.	do.
Turbo sp.	do.	do.	do.
Ammonites sp. ..	do.	do.	do.

PART C.—THE COUNTRY NORTH OF THE DIVIDING RANGE.

I.—INTRODUCTORY.

Leaving Brisbane 7th April, 1921, the writer visited Morven while the horses were being assembled at Injune Creek. At Morven, in addition to observations made by the examination of outcrops, valuable information was obtained from Sergeant Millard both about the bores in the district and the topography of the country to be traversed. Sergeant Millard was one of the police body which hunted down the Kenniffs (a bushranging band), and was stationed many years on Deloogerah Creek near Carnarvon.

On 14th April the departure from Injune Creek was made. Timor Station in the Basal Walloon formation was recrossed, and having been already examined did not cause much delay. The Dividing Range was crossed between Timor and Merivale and found to consist of Calcareous Lower Walloon rocks. These continued to Merivale where the Bundamba sandstones commenced. From Merivale a detour was made to Mount Ogilvie and Eddystone Vale; thence up the Maranoa to Warrong and thence to Mount Moffatt, all in Bundamba sandstone with basalt cappings. From Mount Moffatt the journey was continued *viâ* Warrong to Marlong, where several days were spent in offsetting to points on the Hoganthulla Range. This range was crossed at Geegee Gap, where trachytes intruding the Bundambas were observed.

Thence we proceeded *viâ* Deloogerah Creek to Carnarvon, mostly through basaltic country overlying Bundamba formation. From Carnarvon the journey was continued over the Dividing Range at the head of the Channing, where the range was crossed at a height of over 3,000 ft.

In an endeavour to get into Buckland Creek we got by a cattle-pad into Saddle Creek, a branch canyon, but here found that precipices and waterfalls impeded further progress. The range was reascended and a fresh descent was made this time into Buckland Creek. For the first eight miles along the creek only steep basalt slopes and cliffs were seen, then, as the valley opened out, cane-grass flats on Ipswich shales and yellow Ipswich sandstones became frequent. About twelve miles above Nardoo Station the upper sandstones of the Bowen formation became the country rock. In these were seen caves embellished with a plethora of aboriginal drawings, one of these caves answering to the description of one seen by Mr. Gibb Maitland in 1894 (Ann. Rep. Dept. Mines, 1894). The journey was continued to Nardoo through shales, sandstones, carbonaceous bed limestones, and calcareous formations of the Upper Bowen Coal Measures.

From Nardoo we proceeded to Blue Hills (Colliblue), and after the first four miles (mostly brigalow scrub on Upper Bowen formation) the route lay through massive whitish and yellow sandstones with intercalated red sandstone of the Middle Bowen Series, which in the Blue Hills environment have numerous basalt cappings. From Blue Hills the journey was continued to Mount Sunday, through country consisting mainly of calcareous shales and sandstones at the base of the Upper Bowen Coal Measures. Thence north-north-west to Sypher's station (Hillview) principally through Middle Bowen sandstone. A few miles north of Sypher's, in the north-west corner of parish Sterculia, a limestone bed was encountered, and shales and sandstones are here intercalated after the manner of the Middle Bowen Coal Measures. The journey was pursued in a northerly direction along Yellowberry Creek to the Nogoa, chiefly in the lower sandstones of the Middle Bowen, which becomes very pebbly as Nandowrie Peak is neared. Then a blacksoil plain with every appearance of being of limestone derivation was crossed, this being probably the Marine limestone which is approximately the division between the Middle and Lower Bowen.

The next section was along the Nogoa to Vandyke Creek, chiefly through conglomerates, glacial boulder beds, tills, varve shales, sandstones, and shales with some intercalated rhyolite and diabase—a series which was regarded as Lower Bowen. From Vandyke Creek to Springsure strata of the same kind as first mentioned prevailed for five miles, then Middle Bowen sandstone until the Springsure basalt area was entered.

At Springsure supplies were obtained and then the work proceeded by the examination of Vandyke Creek nearly to the head in a north-south direction, then an east-west cross-traverse from Mount Sunday to Wealwandangie, then a traverse up Coona and Freitag Creeks for some distance and return to Springsure through Cairdbeign. The next journey was from Springsure to Meteor Downs, then up along the Meteor Creek nearly to the head, then across to the upper part of Peawaddy Creek and down along Peawaddy Creek to Consuelo head station: thence up Consuelo Creek to Rewan, near which on Consuelo Creek several important coal-seams of Middle Bowen age were examined.

From Rewan traverses were made south-west to the upper part of Carnarvon Creek where important coal-beds and a kerosene shale deposit were examined, west to Black Alley Peak where important stratigraphical information was obtained and a small area of metamorphic rocks discovered, and south to "The Crater," a peculiar formation of which more will be said later. From Rewan the journey was continued south-east to the Moola-yamber, which was followed up nearly to its source, and a connection made with the point reached on Bullaroo Creek in

the geological survey of the Roma district in the previous year, then down the Moolayamber to the Brown River, then to Warrinilla.

From Warrinilla the inspection was continued down the Brown River to Purbrook Downs, thence up Clematis Creek to Bedourie, and from Bedourie through Glenhaughton and Broadmere to Taroom.

It will be seen, by following these journeys on the map, that the traverse lines crossed and recrossed the Middle and Upper Bowen formations again and again in various places. Thus the observations made on the succession of strata on the traverse from Buckland Creek at its source to the Nogoa were checked and confirmed. Dips were taken at very frequent intervals and data obtained for the computation of the thickness of each series.

It was expected that the Ipswich formation as it occurred at the head of Buckland Creek, and at the head of Bullaroo Creek and in Arcadia Valley, would be met with near the head of Clematis Creek. Anticipations were correct, for at Bedourie the Ipswich formation was found well developed, and on leaving Bedourie further confirmation of petrological diagnosis was seen from the Bedourie hills in the vast Ruined Castle mesas of Bundamba sandstone, one time continuous over Arcadia Valley with the Westgrove-Boxvale sandstone capping the Ipswich beds some five to ten miles to the south. As the map shows, this Bundamba series was crossed completely between Bedourie and Broadmere, and interesting trachyte cappings were observed east of Glenhaughton. Three-fourths of the travelling was bush travelling with no roads and few reliable pads, much through wild gorges and over ranges.

The few stations passed on the journey rendered all the assistance they could, and to the following gentlemen the writer is particularly indebted for assistance rendered and information given—viz., Sub-Inspector Campbell at Rewan, Sergeant Millard at Morven, Sergeant Mackereth at Alpha, and Messrs. Slatyer, Donkin, Ogg, and Leslie of Wealwandangie, Meteor, Consuelo, and Warrinilla Stations respectively.

In addition to the studies involved by the itinerary shown above, the writer and Mr. Geologist Saint-Smith also spent several days examining the Star Beds between Bogantungan and Hannam's Gap, and the writer also went to Alpha where he examined the environment and got useful information about the extent of the Star Beds in the Mount Beaufort direction. The country around Emerald and also the country along the Emerald-Springsure road were examined as well. While this work was proceeding, Mr. Shepherd, geological cadet, carried on the work of examining the igneous rocks around Springsure and Minerva, for the purpose of the present report.

II.—PHYSICAL FEATURES.

The Carnarvon Ranges form a portion of the Great Dividing Range, and the spurs from same. One spur dividing the Moolayamber basin from the Dawson Valley is known as the Carnarvon Range, but for the purpose of this report it is better to speak of all the ranges between Boxvale and Carnarvon Station as the Carnarvon Ranges.

The other principal spurs are the Hoganthulla Range, the Warrego Range, the Buckland Range, the ranges between Vandyke, Coona, Freitag, Meteor, Peawaddy, and Consuelo Creeks, Black Alley Range, Morella Range, and the Expedition Range.

The Dividing Range (or principal range of the Carnarvon Ranges) is a mere low divide between the Maranoa waters and Injune Creek. From Kilmorey to Mount Hutton it is over 2,000 ft. high and basalt-capped. North of Mount Hutton, where it divides the Injune waters from the Merivale waters, it is again a low divide composed of sedimentary formations until the Mount Hetty region is reached, which is basalt-capped and rises to well over 2,000 ft. on the average. There is a gap north of Mount Hetty after which the Dividing Range takes a north-west direction to Carnarvon Station at the head of the Warrego, and is basalt-capped for most of that distance. The average height of the range between the head of the Moolayamber and the head of the Warrego is well over 3,000 ft., and many points probably reach 3,500 ft. in altitude. North of this part the basalt sheets spread over a large area forming the Buckland Tableland, which is about 3,000 ft. in average altitude. Some of the northern legs of this basalt mass are of lower altitude, and are in places locally known as the Buckland Tableland, a fact which may lead to confusion, but the name should be properly speaking applied only to the high area at the head of Vandyke Creek and its tributaries. The Dividing Range at Carnarvon Station takes a swing to the south-west, and north-north-west of Boggarella, in the region of Mount Playfair, it again becomes a mere divide easily crossable.

The Hoganthulla Range west of Warrong is a remarkable residual range consisting of a long, narrow table of sandstones of Bundamba age, which northward towards the Dividing Range becomes basalt and trachyte capped, and which followed to the south-south-west also becomes basalt-capped and expands into a basaltic tableland round Mount Tabor which might be termed the Hoganthulla Tableland.

The Dividing Range at the head of the Maranoa is perched on a sandstone tableland which was somewhat dissected prior to the basalt effusions, and which averages over 2,000 ft. above sea-level, shelving gradually to the south. This sandstone tableland is best termed the Maranoa Tableland in the Maranoa-Merivale basin and the Carnarvon Tableland in the Babbiloora to Carnarvon region or Warrego region.

The sandstones which underlie the basalt were much more dissected in the regions north of the Dividing Range than in the country south of it. Prior to the basaltic effusions there was a sandstone tableland with bold precipices over 1,000 ft. in height, wide open low-level erosion valleys with cliff walls and mesas more or less disjointed on the areas of greatest erosion. Over such an irregular surface the basalts flowed and volcanic necks formed both in the highlands and the lowlands

On the Maranoa Tableland there are various disconnected basaltic cones such as Mount Moffatt, Mount Ogilvie, Mount Eddystone, Mount McLeay, the Observatory, and others, some of which may formerly have been connected with the major flows, but some of which were probably independent foci of eruption. Sufficient evidence was not seen to enable one to say which mountains are mountains of volcanic accumulation and which owe their nature to dissection, and the question is purely one of academic interest and has no practical value. Similar mountains not connected with the ranges lie in other sectors thus:—In the Warrego sector, Mount Hopeless near Barngo: Mount King and Mount Tabor at the head of Hoganthulla Creek; Rothesay Peaks, Mount Caroline, Mount Vexation, &c., in the Vandyke sector.

Between the Vandyke basin and the Meteor Creek basin there stretches a continuous high belt of basalt from the Buckland Tableland to Springsure. Many of the higher peaks of this area like Mount Hope, Mount Catherine, Mount Rainworth, and Mount Kelman are probably relics of independent foci of eruption, the flows from which have been merged into one basaltic plateau.

The country lying between Consuelo and Warrinilla is rangy, but most of the ranges are sandstone residuals of Bowen age. The Morella Range is also an outcrop of harder sandstones left by the Moolayamber and its tributary the Morella, the latter having worked down in the softer formations lying to the south of it.

The Expedition Range appears, by the examination made of it at its southern end, to be of a heterogeneous character, and not, as formerly believed, of uniform composition. It is merely the western front of the remains of a tableland which occupies a synclinal axis. When the range is ascended by Clematis Creek from the Warrinilla side, one gets up on a tableland at Bedourie which stretches away to the east, but becomes gradually lower in that direction except where ranges of residual Bundamba sandstone rest on it, as at Roper's Pass and along the Ruined Castle and Glenhaughton Ranges.

The Bedourie, Ruined Castle, and Glenhaughton Tableland is continuous physiographically and genetically with the Westgrove-Boxvale Tablelands, from which it is separated by

the head waters of the Dawson and Brown Rivers, which form a maze of deep canyons and gorges that are a serious obstacle to quick and easy communication between the two analogous blocks.

One of the most interesting facts about the Carnarvon Ranges is that they form practically the roof of Central and Southern Queensland, and are the source of the head waters of a great many river systems including the Condamine, the Maranoa, the Warrego, the Thomson, Barcoo, Cooper's Creek, the Belyando, the Nogoa, the Brown, and the Dawson; hence some of the waters falling in this region find their way into the Darling, others into Lake Eyre, others into the Burdekin, and others into the Fitzroy. Sedimentary rocks are obtained up to a height of 2,500 ft. in the Warrong and Carnarvon Station areas, but in other parts all ground over 2,000 ft. is in general basaltic.

The scenery is extremely varied. The head waters of the Dawson River and of the Brown River about Boxvale, Arcadia, Lonesome, and surrounding parts give magnificent scenery of the Blue Mountain (N.S.W.) and Hawkesbury type, since they dissect Bundamba sandstones (which in the writer's opinion are the equivalents in age and stratigraphical succession to the Hawkesbury sandstone of N.S.W.). The canyons have vertical and inaccessible walls ranging from several hundred to nearly a thousand feet high of beautiful white and yellow sandstone.

In the region of Warrong, Mount Moffatt, and Carnarvon Station we get scenery more of the volcanic type, not unlike the Canobolas in N.S.W., consisting of basaltic cones and more or less dissected tablelands of basalt, showing distinctly that terracing which results from flow following flow. There is a sandstone basement which shows in places in the range, and becomes the prevalent country as the Dividing Range is receded from. The country is beautiful and park-like, the domes often covered with the most highly ornamental trunked zamias, which frequently, as on Lyon Mountain (Carnarvon-Deloogerah), are spaced as though planted purposely. The tablelands are easily accessible by stock and are covered with rich mountain grass.

Across the divide among the head waters of Buckland Creek, Vandyke Creek, and Meteor Creek we have another type of basaltic scenery. Deep canyons have been carved in massive basalts exceeding 1,500 ft. in thickness. The basalts in birdeye views show a succession of flows. Every canyon is lined with steep escarpments, grey and black cliffs of jagged basalt, and steep slopes covered with huge boulders. Great landslips have left enormous piles of talus in the valleys. The tablelands of basalt are so inaccessible in this region that they are seldom climbed by stock. Travelling except along the creek-beds is impossible with horses.

The ridges, mesas, and tablelands of Bundamba sandstone which cap the Glenhaughton-Reedy Creek area consist of very

poor country, but at the time of examination the wattles, grevilleas, boronias, hoveas, dillwynnias, and hardenbergias were out in flower, yielding an exceedingly beautiful landscape of wild flowers, reminding one of the Blue Mountains (N.S.W.) in the flowering season.

The sandstones of Upper Bowen age met with on Clematis Creek and the Moolayamber are like the Bundamba sandstones, dissected by gorges which, however, are not so precipitous, for these sandstones are less even-textured, are more strongly bedded, and have frequent ferruginous and shaly bands, hence they form rough, steep, stony slopes alternating with small precipices and thus the canyons have terraced walls. It is naturally easier to find a convenient point for ascent in this type of country.

In discussing the mountains, one has had to refer to the rivers and their tributaries. Some additional remarks are, however, necessary. The head waters of the Maranoa and Merivale run in gorge-like beds carved in the sandstone plateau of Warrong and Merivale. These gorges could easily be dammed to supply a water scheme for the irrigation of the Maranoa district if the silts carried down are not found to be too coarse. Gorges are also common in the sandstone areas of the Hoganthulla Range and on Carnarvon Station at the head of the Warrego, as is also the case at the head of the Nogoa near Mount Playfair where the Bundamba sandstones cross the range.

Vandyke Creek, a tributary of the Nogoa, is remarkably straight and runs very fast in wet weather, since it drops about 2,000 ft. in twenty miles. It runs from south to north and is a very straight creek, and occupies the position of the axis of a very gentle anticlinal undulation in the Bowen beds which, having originally a gentle southerly dip, are tilted slightly south-east east of the creek and south-west west of the creek.

Meteor Creek, which finds its way into the Comet River, pursues also a very direct course in the mountainous regions, but it will be noticed on the map that when the low country is reached (about 800 ft. above the sea-level) this creek and also its neighbour the Peawaddy Creek swing from an almost north-north-east course to an easterly course, but they still remain "consequent" streams—i.e., they cross the geological horizons instead of pursuing the same direction. However, Consuelo Creek, Carnarvon Creek, Moolayamber Creek, and also the Brown River are for the most part subsequent streams running roughly parallel with the line of strike in their respective regions. These streams have not been greatly changed by basaltic extravasation, but it is a remarkable fact that each of these creeks and the Areadia, which together form the Brown River, constitute as large if not a larger creek than the Brown itself, just as though a considerable intake of water took place in the swampy belt of country about Warrinilla and Lake Nuga. After passing

through a belt of sandstone below Warrinilla for ten miles (The Gorge), the Brown River again expands into a swampy flat. The river loses itself into a maze of channels, some of which come together and form the Comet.

It is worthy of note, too, that Moolayamber Creek, which has a very large channel, was examined about two weeks after 5 in. of rain had fallen, yet its bed was bone-dry except near the head. This creek runs through the same belt of formations that outcrop under the swampy plain of Warrinilla and Nuga Nuga. It is possible that these facts may have some significance in connection with our artesian problems.

Plains and Downs.

Where the creeks flowing northward leave the rough basalt country, the usual landscape met with on sedimentary rocks becomes prevalent. We see areas of sandy-loam forest country spreading over the various sandstone formation; belts of brigalow-belar-wilga scrub covering the very calcareous formations especially the Upper Coal Measures; areas of beautiful clump brigalow country with patches of brigalow-wilga scrub cover the calcareous Ipswich formation, whether in the high lands or in the low lands. Other level areas clad with scrub are bestrewn with "billy" (boulder quartzites and cherts), of which more will be said later. Again, in other places we get open blacksoil plains especially on wide flats where basaltic detritus is intermixed with the detritus from the Upper Bowen Coal Measures. Such mixed soils are found on the Mount Sunday plain west of Mount Sunday, on the Vandyke plain where Vandyke and Spring Creeks join, and on the Wealwandangie plain. This country is grand fattening country and ideal for sheep, and the entire belt of the Upper Coal Measures is rather saline, growing an abundance of saltbush, and especially the basal beds which are marine and contain also gypsum.

This same belt contains very little basaltic wash in the Carnarvon Creek and Brown River basins, where, accordingly, the soils are more sandy yet rich and heavy. The salinity persists along the basal beds of the formation and is demonstrated along Morella Creek by saltbush and couch, brigalow and belar, and at Warrinilla and Lake Nuga as well as at Lake Brown by huge swampy tracts covered with saltbush and saline couches, and at the time of inspection teeming with water-birds—ducks, divers, black swans, geese, pelicans, native companion, plover, ibis, and innumerable others. The country was a facsimile of the sort of country seen on the salt marshes along the sea-shore, except for the poplar box which grew in patches, and the brigalow-belar which here replaced the coastal mangroves and swamp oak. It is interesting to remark that on Meteor Downs, which has the

Upper Coal Measures belt of Meteor Creek completely covered up by basalt, the country is poor in salt and the stock require salt, proving clearing that the salinity is not derived from basalt. On Warrinilla and Wealwandangie the stock do not require salt.

Soils and Vegetation.

A brief description of the soils is essential, since often, where outcrops are covered up, the geologist must be guided in his mapping by the character of the soil and vegetation. The metamorphic rocks of the Anakie formation in the area under review have a comparatively poor soil with a stony rubble intermixed. The rubble consists of fragments of schist, granite, porphyry, quartz, and other rocks common in such formations. A species of yellow bloodwood (*Eucalptus Watsoniana*) and gumtop ironbark were the principal timbers on this formation west of Rewan.

The Lower Bowen conglomerates in the Nogoa quadrant yield a bouldery and stony poor soil with pine (*Callitris calcarata*) and wattle scrubs on the summits. The broad-leaf ironbark (*E. melanophloia*) grows on the better parts. The associated sandstones and tills yield light loams of good quality on which we get principally coolibah and gumtop box (*E. microtheca* and *E. hemiphloia*). The more calcareous beds have also bauhinia.

"Billy" yields a stony soil like the Lower Bowen conglomerates, but is generally covered with brigalow-belar-sandalwood scrub where it does not form open plain. The limestone areas, whether Lower Bowen or Middle or Upper, yield heavy black soils which often constitute open plains, but are also frequently covered with brigalow scrub; they generally support a considerable amount of saltbush and in some parts nardoo.

The Middle Bowen sandstones in the Nogoa quadrant yield poor to medium soils which, however, are fairly well grassed; the principal timbers are pine (*Callitris calcarata*), yellow bloodwood (*Eucalyptus trachyphloia*), bloodwood (*E. terminalis*), apple (*Angophora intermedia*) sugar-gum (*Angophora lanceolata*), Moreton Bay ash (*E. tesselaris*), crooked gum (*E. dealbata*), and grass-tree (*Xanthorrhœa*). Where, however, the sandstone beds become more calcareous we get a richer soil with box (*E. populifolia*) and ironbark (*E. melanophloia*).

In the region of Meteor and Consuelo Creeks the Lower Bowen conglomerates and Middle Bowen sandstones are the favourite habitat of spotted gum (*E. maculata*), which in some localities, as on Meteor and Sandy Creeks, is the lemon-scented variety (*citriodora*). The gumtop ironbark (*E. decorticans*) and the narrow-leaf ironbark (*E. crebra*) often accompany the spotted gum, and in other places the yellow bloodwood (*E. trachyphloia* and *E. Watsoniana*) and the bloodwood (*E. terminalis*) occur with the spotted gum.

Most of the sandstones of the Bowen formations contain sufficient falspathic material yielding potash, and calcareous cement yielding lime, to be considered well-balanced though not rich soils.

The calcareous sandstones where very high in lime yield heavy black soils with brigalow-belar scrub. The coal measure formations consisting of close interbedded sandstones, shales, and calcareous rocks yield a mixed soil usually of a light-grey or brownish colour. It is inclined to be clayey and heavy. On the more calcareous portions we have black soil with mulga-belar-brigalow scrubs, and on the greyer soils Moreton Bay ash (*E. tesselaris*), coolibah (*E. hemiphloia* and *E. microtheca*), and in the Nogoa quadrant particularly the poplar box (*E. populifolia*). In the Meteor-Consuelo quadrant the more coastal nature of the country brings in the swamp mahogany (*Tristania suaveolens*), and some spotted gum (*E. maculata*). Ironbark (chiefly *E. melanophloia*) occurs in patches especially on the higher grounds. In addition, we get *E. rostrata* well represented on this series in the Nogoa division.

The great thicknesses of alluvial accumulated on the flats along the Nogoa and Brown Rivers, and on many of the tributary creek flats, are chiefly covered with coolibah (*E. microtheca* in some places, *E. hemiphloia* in others).

Coming now to the Upper Bowen formations, we have the basalt and limestones with soils and vegetation as already described for limestones generally, the coal-bearing series which have soils and vegetation similar to those of the Middle Bowen coal belt, and the upper sandstones which support chiefly spotted gum, gumtop ironbark (*E. decorticans*) and lancewood (*Acacia doratoxylon*). The soil of these upper sandstones is stony and gravelly, quite unlike that of the Bundamba sandstones.

The Ipswich coal measures in the Carnarvon Ranges consist of a lower yellow sandstone, very felspathic, yielding good light loams which support a forest rather rich in species of eucalyptus including spotted gum (*E. maculata*), ironbarks (*E. melanophloia, E. creba,* and *E. decorticans*), stringybark (*E. acmenioides?*), boodgeroo (Lysicarpus sp.), with river gum, apple, tea-tree, and oak along the creeks.

These sandstones become more and more calcareous upwards in the series when the molly box (*E. rariflora*) and the poplar box (*E. populifolia*) take the place of stringybark and budgeroo. The soils become at the same time richer looking, less sandy, and take on a reddish brown colour. When the Upper Ipswich strata are reached, which are indeed true limestones and limy shales without fossils, we get reddish brown heavy clay soils with mulga-brigalow-belar scrubs. On the Ipswich formation clump brigalow is fairly common, indeed rather more frequent than continuous brigalow belts. These soils are very rich.

The Bundamba sandstones yield very poor, light-grey, very sandy soils which support in the Glenhaughton districts a very rich flora of wattles and flowering shrubs. The chief eucalypts are tumbledown gum (*E. dealbata*), spotted gum (*E. maculata*). Moreton Bay ash (*E. tesselaris*), stringybark (*E. acmenioides?* Angophora-like variety), gumtop ironbark (*E. decorticans*), yellow bloodwood (*E. terminalis*); and on the richer flats and shaly bands ironbark (*E. melanophloia*), poplar box (*E. populifolia*), and molly box (*E. rariflora*). With the eucalypts on the most silicious sandstones we get the wattles (*Acacia Cunninghamii, A. macradenia, A. nereifolia, A. polybotrya, A. flavescens, A. conferta, A. Bancrofti*), boodgeroo (*Lysicarpus ternifolius*), *Casuarina inophloia, Angophora intermedia,* and *Angophora lancifolia:* also leptospermums, hoveas, dillwynnias, boronias, clematis, hardenbergias, hakeas, grevilleas, *Jacksonia scoparia, Petalostigma quadriloculare* (quinine), grass-tree, wooden pear (*Xylomelon pyriforme*), and trunkless zamia. This country is practically useless.

The Walloon series at Taroom is characterised by the same heavy clay soils rich in lime as at Durham Downs and Toolumbilla. We get principally brigalow-belar scrubs with a considerable sprinkling of bauhinia, sandalwood (*Eremophila Mitchelli*), ooline (*Cadellia pentastylis*), emu apple (Owenia), wilga (*Geijera parviflora*), &c.

The basalts are characterised principally by their silver-leaf ironbark (*E. melanophloia*) and gumtop box (*E. hemiphloia*) forests with an abundance of zamia on reddish brown to black soils, which contain fragments of rock crystal. Where basaltic soils form plains the rock crystal is the test for discrimination from limestone soils, which contain in its place scattered pieces of polished chert.

Before leaving this subject a few words might be said about the soils on the Drummond series. The upper portion of this Carboniferous series, being limy mudstone with fish remains and limy shales, yields a fair but gravelly soil on which the dominant timber on the ridges is broad-leaf ironbark (*E. melanophloia*), but on the flats we get also bauhinia, *E. populifolia, E. hemiphloia, E. microtheca,* wilga, sandalwood, brigalow clump, and *Ficus aspera.* On the flat country at Bogantungan *E. tesselaris, E. rostrata,* and *E. terminalis* are also common. The lepidodendron-bearing sandstones yield sandy soil in which the ironbarks and quinine figure prominently.

Peneplains and Pre-Basaltic Physiography.

The sandstones in many parts of the Main Dividing Range reach an altitude of 2,500 ft., and, as shown in the previous report, they reach in places in the Mount Hutton and Kilmorey Ranges 2,300 ft.

Early in the Tertiary period there was a peneplain which is now represented by the 2,500-ft. level. This was uplifted and tilted towards the south, slightly plicated and faulted in places by an elevatory movement having its maximum energy somewhere in the Drummond Range.

Dissection of the peneplain proceeded and great valleys were formed by the ancestors of the Fitzroy tributaries. Thus a great block of elevated tableland country was formed more or less dissected, and stretching from the Warrego through the Upper Maranoa district, Westgrove, Boxvale, and Glenhaughton. Then basaltic activity commenced.

The basalts completely filled up a great open valley which formerly occupied much of the country along an east-west belt from Mantuan Downs to Rolleston. Streams flowing from the Drummond Range into this valley were diverted. The drainage of the country changed, and the waters of the Upper Nogoa had to find a way round the volcanic pile stretching from the head of Meteor Creek to Springsure.

In the Late Cretaceous or Early Tertiary prior to the dissection of the rising peneplain there seems to have been a glacial period which has left its traces far and wide.

After the basaltic extravasation which was probably Middle Tertiary (Miocene), a large number of new streams developed such as Vandyke, Cona, Freitag, Meteor, and Peawaddy Creeks. These are consequent streams. Consuelo, Carnarvon, and Moolayamber Creeks are older subsequent streams.

Tumbledown Hills.

An interesting feature in the upper strata of the Middle Bowen is a formation which consists of yellow sandstones overlying red shales which in cliff exposures are completely weathered to red clays. This formation forms a belt which passes through Sypher's, 1 and 2 parish Sterculia, 17 and 18 parish Cona. We lose it under basalt between Freitag and Springsure. According to information received about bores in the region of Peawaddy Creek, and the strata outcropping at the stockyards near the Sugarloaf, not far from the head of Peawaddy, this formation comes out here, swings south through the Rocky Creek valley, and recurs east of the great fault about twelve miles further south at the head of Oaky Creek, parish Aubrey; thence the formation can be traced eastwards through the Morella Range south of Rewan and takes on a north-east direction so that we get it between Rewan and Warrinilla and along the west banks of the Brown River.

In this formation undermining proceeds in the soft red clays and the overlying sandstones tumble down, so that ridges

of a very broken and disintegrating appearance are developed. Very deep soils form below these ridges and swamps are produced in considerable abundance.

A smaller belt of the same type occurs in the Upper Bowen and was particularly noticed on the Moolayamber near the junction with Bullaroo Creek.

"Billy."

The widespread occurrence of "billy," a surface formation consisting of smooth polished boulders of quartzite and chert, deserves a brief reference. This formation has been referred to by Mr. Dunstan in three important papers.*

In Bulletin 148* Mr. Dunstan gives a very full description of several "billy" occurrences with sections. The present writer has seen both on the southern and northern sides of the Carnarvon Ranges numerous occurrences of "billy" similar to those described by Mr. Dunstan, where the evidence absolutely tends to show that the "billy" is not so young as the basalt of the same district, and has therefore not been formed by the basalt sheets fusing underlying sandstones.

The section at Black Ridge is comparable to the section of Mount Bindango north of Muckadilla, where a surface chert formation in process of disintegration to angular blocks caps the mountain 500 ft. or so above the basalt flow near the base.

This chert is not yet "billy," but is in process of forming "billy."

Mr. Dunlop and the writer also noticed in several places, as at Oaky Creek near Mount Hutton, and under the basalt cappings near Amby, that the basalts have frequently flowed over pre-existing "billy" formations. The writer entirely concurs with Mr. Dunstan's suggestion regarding the origin of "billy"—viz., that "billy" has been formed by some surface action and that this action affected the sandstones of all ages that were exposed at the time. The action affected calcareous mudstones as well as sandstones, yielding those yellow cherts which are so abundant in all the "billy" accumulations in the areas north and south of the Carnarvon Ranges. This accounts for "billy" with fossil remains being occasionally found.

From the investigations made in the country north and south of the Carnarvon Ranges it is obvious that the period of "billy" formation was immediately before the Desert Sandstone (Cretaceo-Tertiary). All formations exposed at that time exhibited a tendency to surface silicification. No doubt this was

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*Bull. 148, The Permo-Carboniferous Coal Measures of Clermont, &c. Brisbane, 1900.

Bull. 155, The Geology of the Dawson and Mackenzie Rivers. Brisbane, 1901.

Bull 172, The Sapphire Fields of Anakie. Brisbane, 1902.

due to the period being one of great aridity, which led to surface silicification by the capillary rise of alkaline silica-bearing waters in the same way as is going on to-day in Central Australia. The writer has seen evidences of the same process going on at the present time in places in the Northern Territory.

The arid period was probably contemporaneous with the first slight uplift of the peneplain referred to above. As uplift continued, wetter conditions came in, and we get a glacial period, for, as already stated in Part B, we can only account for the peculiar structure and distribution of a large proportion of the "billy" mounds on a glacial hypothesis.

The period of this glaciation would coincide with that recently noted in Western Australia,† and floating ice also affords an explanation of the boulder mounds in the Central-West and Longreach district, where polished granite, porphyry, and other boulders occur in regions far remote from any formations of that kind.

Again, it should be mentioned that the "billy" mounds in the Orallo and Mount Hutton districts were found to contain a limited number of polished boulders of granite porphyry, slate, and quartz which certainly were not derived from the locally formed "billy," but must have come from the Anakie or Camboon region.

The localities north of the Carnarvon where "billy" has been found in ridges and deposits comparable to those of the Mount Hutton district are—(1) Vandyke Creek, parish of Uranna, Osmondthorpe, and Cona; (2) Consuelo Creek, parish of Sericold; (3) Morella Range, Moolayamber Holding; (4) Warrinilla; (5) Bedourie; (6) between Glenhaughton and Broadmere, and other places.

Those of Vandyke Creek bear the closest resemblance to actual moraines, and indeed the linear direction of Vandyke Creek, as well as the hanging nature of some of the pre-basaltic valleys at the heads of Vandyke, Meteor, and Consuelo (as far as the basalts allow the observer to judge), are points favouring a glacial hypothesis.

At Vandyke Creek the position is confused by the proximity of and the actual outcrop in places along the Cretaceo-Tertiary moraine (?) material of the glacial conglomerates and tills of Lower Bowen age. These too give a "billy" surface, but the boulder hills of that formation contain an abundance of granite, porphyry and porphyrite, and reef quartz; whereas the Vandyke Tertiary mounds contain very little of these rocks, and consist mostly of the same yellow cherts and white quartzites as the Mount Hutton "billys," and rather frequent pieces of black chert. In one ridge the writer found a chert replacement of a Bowen shell either Edmondia or Eurydesma.

† By Dr. Woolnough.

It is important to note that in all the writer's experience the Cretaceo-Tertiary "billy" had a fairly rich soil, though very stony, as evidenced by the calciphile flora, which includes brigalow, sandalwood, wilga, broad-leaf ironbark, poplar box, &c., while the boulder beds of Lower Bowen age are generally poor in soil and support calciphobe vegetation such as pine, narrow-leaf ironbark, sugar gum, spotted gum, stringybark, and yellow bloodwood.

Aboriginal Records.

There are in the Carnarvon Ranges innumerable caves, many of which are reputed to contain large numbers of aboriginal skeletons. The writer has not seen any of these burial caves personally, but has seen on stations skulls and skeletal remains obtained from some of them. However, in searching for fossils, many large caves were visited, and in most of the caves capable of giving shelter to aboriginals there was an abundance of cave paintings, most of which were made in the usual way of placing an object on the wall and blowing out of the mouth a liquid colouring matter around the object it was desired to represent. In caves of white sandstone the artist used red ochre, and in caves of red sandstone some white clay pigment. In addition to pictures made in this way of hands, boomerangs, kangaroos, emus' feet, stone hatchets, spears, &c., there are innumerable genuine drawings. Gibb Maitland mentions having seen some of these caves on Buckland Creek, where the writer saw several proper drawings of aboriginals in full war regalia, or naked with the genitals exaggerated, of echidnas, squirrels, ornithorhynchus, birds, fish, and so forth, very abundant.

A student of aboriginal art could get much material for research by visiting the caves principally on Buckland Creek, Morella Creek, Moolayamber Creek, Clematis Creek, Glenhaughton, and the Ruined Castle Range.

Scenery.

The grand canyons of the Upper Dawson and Arcadia, with their long stretches of inaccessible white cliffs, have already been referred to. The canyon of the Upper Moolayamber is of the same nature. The sombre grey and black walled basalt gorges and steep bouldery slopes at the heads of the Vandyke, the Meteor, and the Peawaddy have also been touched upon; also the less rugged and consequently infinitely more useful basalt cones and tablelands at Carnarvon, whose entire physiography exudes the air of smiling beauty. The remarkable "mesa" range of the Hoganthulla divide has also been mentioned, also the Clematis gorge, which like many at the head of the Dawson and the Moolayamber teems in aboriginal "hand" caves, and have an air of weirdness and melancholy. The tinkling of the horse-bells at night sound and resound, reverberate from cliff to cliff, from cave to cave, and mingled with

the moan of the cascades reminds one of the howls of the hungry ghosts of Orcus or of the werewolves of some tale in the "Arabian Nights."

Remarkable arcs of sandstone, the product of disintegration, remain in several places. The arc of Marlong is the most beautiful of these, and as perfect as though built by a body of giant masons; only a few yards wide and a yard in thickness at the centre point, the upper side practically a plane, the lower a gentle arc spanning nearly 100 ft., and raised at the centre point about 30 ft. from the ground.

The volcanic scenery at Springsure is also unique for its kind. Rhyolites, trachytes, and basalts are all represented and lend their impress to different parts. Rhyolitic bluffs overlying basalt account for the rugged nature of the bluffs, immediately northward of the town. Further north, scenery of the Glass House Mountains and Nandhewar (N.S.W.) type is developed at the Mount Peter and Little St. Peter peaks and others west of Minerva, where trachytes and rhyolites and breccias predominate.

Rainfall and Water Supply.

The average annual rainfall of Springsure is 24·88 in. and of Rolleston 25·17, and of Tambo 14·34 in. over 42 years. The distribution of the rainfall for Taroom through the year, based on the average of 19 years' records, is as follows:—

Month.	Taroom. Pts.
January	395
February	342
March	344
April	188
May	187
June	165
July	133
August	117
September	146
October	183
November	285
December	251
Total	2,736

Average of 21 in. for 19 years.

Springs.

All the creeks heading in the Carnarvon Range with few exceptions have springs, in many cases powerful springs at their source, generally near the junction of the basalts and the

underlying sedimentary rocks. The creeks are kept running perennially for many miles by these spring waters. It is only where the fall diminishes and the creeks enter alluviated plains that they cease to run. Unfortunately the spring region is not too well suited for stock, although well grassed, for it is the roughest part of the mountains and abounds in zamia, which is poisonous and causes rickets in cattle.

Whether these springs emit only waters taken in over the higher parts of the mountains, or also water absorbed in the porous strata of the Middle and Upper Bowen as well which would be borne south along the dip planes, remains an unsolved problem. If the springs are in part artesian, their flow must be due to gas pressure, which would expel the waters along the volcanic fractures and dyke walls that impede their southward flow.

A few salt springs also occur in the area. The writer has not personally seen them, but has been informed of them by men whose testimony seemed thoroughly reliable. The localities where salt springs are reputed to exist are (1) at the head of Consuelo Creek, (2) at the head of Carnarvon Creek, (3) at the head of Moolayamber Creek, and (4) on Tommy's Creek, a tributary of Clematis Creek. The localities mentioned all lie in one belt, viz., the top of the Upper Bowen formation. This is interesting in view of the fact that the lower beds of the Upper Bowen formation are saline as shown by the vegetation. At Mount Moffatt there is a spring emitting inflammable gas which will be referred to later. On Crystalbrook sulphur springs occur.

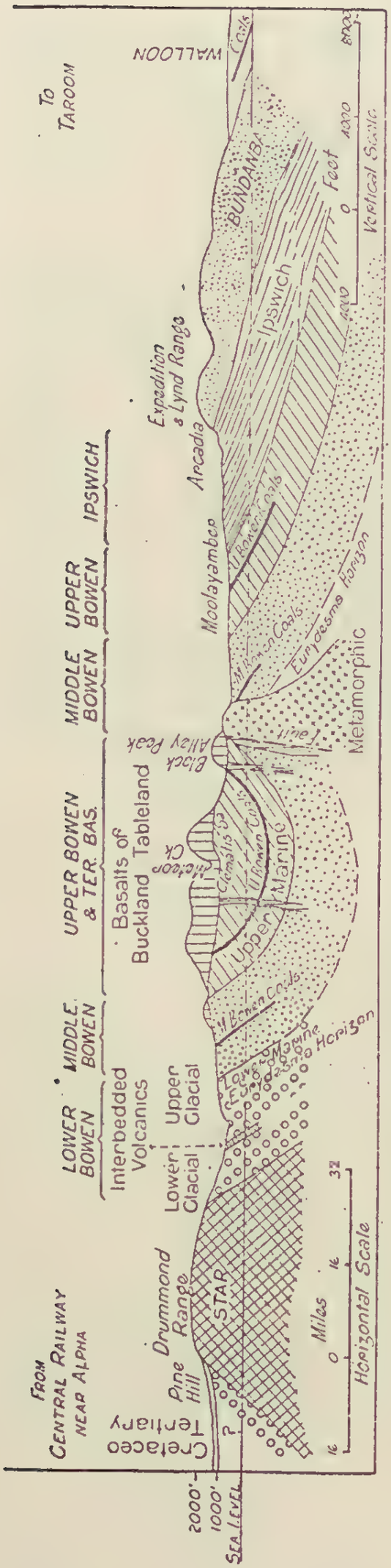

Fig. 12.—Ideal Section from Taroom to the Auburn Range, illustrating structure.

III.—GEOLOGY.

General Review.

The area examined is a vast stretch of rough country which has never been traversed by any geologist before, though isolated points near the avenues of easy communication like Springsure have been periodically visited, and Gibb Maitland got some distance up Buckland Creek.

It is necessary to point out here that the area under discussion in the present report is unique for observing the relations between all the rocks from the Star beds to Ipswich, because even the Star beds of the Drummond Range are only very gently folded and a complete series of Bowen formations is met with up the creeks heading in the Carnarvons, which is not contorted and cross-faulted and thrown into inextricable confusion as is the case with the same formations at Gympie and in the coast ranges generally.

The geology of the Roma and Mitchell side of the Carvarvons has already been dealt with, and sequence of beds from the Ipswich to the Cretaceo-Tertiary has been worked out from the head of the Moolayamber to Roma. We have, therefore, a complete section from near the base of the Star Series to the Cretaceo-Tertiary (Desert Sandstone).

It has been ascertained, by running up

numerous main creeks into the Carnarvons both south and from north, that the entire area is divisible into belts which strike roughly west-north-west representing the surface extent of each geological formation. The area has been divided into the Star area, the Lower Bowen belt, the Middle Bowen, the Upper Bowen, the Ipswich (= N.S.W., Narrabeen), the Bundambas (= Hawkesbury Sandstone, N.S.W.), the Walloon, the Lower Cretaceous (Rolling Downs), the Upper Cretaceous or Cretaceo-Tertiary Desert Sandstone, each of which excepting the last two is also divisible into sub-formations or horizons. These formations succeed one another with remarkable regularity and are only seriously displaced by the great Springsure-Meteor-Sericold anticline, which for briefness will on subsequent pages be called the "Sericold" anticline, and by the fault which follows the western limb of the anticline and has downthrown the western side.

No unconformities have been definitely noticed except that between the Rolling Downs and the Desert Sandstone, and that which occurs where we have minor patches of Tertiary rock or detritus. However; it is certain that the Lower Bowen series is unconformable with the Star, for three reasons—viz., (1) the Star beds, though only gently folded in the Drummond Ranges, are more indurated, more folded, and more irregularly folded than the Lower Bowen beds; (2) the Lower Bowen beds commence with great conglomerate formations which imply land or shore conditions and are equivalent to an unconformity; and (3) the Lower Bowens include a great glacial series which implies land conditions near-by during part of the period.

It is also important to note here that, although the Upper Bowen, Ipswich, Bundamba, and Walloon formations appear quite conformable, there may be gaps in the sequence, especially between the Ipswich and Bundamba, and the Bundamba and Walloon formations, which are separated by conglomerates. The apparent conformity may be due to isostatic movements of vertical uplift or depression affecting a vast area uniformly and contemporaneously. The whole of these formations from the Upper Bowen to the Cretaceous are, as far as known, mainly freshwater, and in such a period of lacustrine conditions there may have been intervals of drainage, though present evidence implies almost continuous sedimentation.

Tenison-Woods, in his celebrated paper on "The Desert Sandstone,"* regarded as "Desert Sandstone" numerous sandstones which we now, in the light of subsequent researches, consider to be of Jurassic, Bundamba, or even Permo-Carboniferous age. He further considered these sandstones as being largely of Æolian origin, basing this view on the microscopic structure of the sand-grains. This certainly supports the theory that there was not continuous marine or lacustrine sedimentation

* Royal Soc. N.S.W., Nov. 7, 1888.

in the periods mentioned. Certain it is that, whether our mesozoic sedimentation was continuous or not, all our Western formations from the Ipswich to the Lower Cretaceous must be regarded as Epicontinental in origin; and it becomes largely a question of definition whether all formations from the Star onwards should not be considered Epicontinental, the thin Marine Series noticed in the Lower and Upper Bowen and the much more formidable Cretaceous Marine as mere marine phase due to a *positive* movement of the sea. But the fact still remains that the large area of mesozoic sedimentation in Queensland was a synclinorium or constituted a great structural depression on the face of the continent. In Part B the Walloon, Bundamba, and part of the Ipswich formations have been described in considerable detail. The Bundamba sandstones were traced through Pony Hills, Boxvale, Westgrove, Crystalbrook, Eddystone Vale, Warrong, Marlong, and Carnarvon; yielding the same sandy soil clad with carpet grass and calciphobe forest trees like the sugar gum (*Angophora lanceolata*), tumbledown gum (*E. dealbata*), stringybark, boodgeroo, &c. On the better parts poplar gum and ironbarks are found as well, and on the poorest parts sandy pine country. The sandstone series contains occasional intercalations of shale.

From Carnarvon Station along the Charleville road to Barngo the character of the country is uniformly that yielded by the Bundamba Series. However, from Babbiloora to Boggarella the country is brigalow-belar scrub with little plains as at Injune Creek and Durham Downs. The station bores put down for artesian water passed through strata containing fossil ferns (probably Cladophlebis) and the principal rock met with was shale. No doubt this is the Lower Walloon. Further south at Killarney, coal is found in Hoganthulla Creek outcropping in fair seams and having the same characters as the coal in the Maranoa at Forest Vale. This coal is probably the equivalent of the Forest Vale and Orallo coals, and must therefore be regarded as Middle Walloon.

Cretaceous fossils occur at Caroline.

The Walloon belt is roughly bounded on the south by the line of division shown on the early maps of Mr. Gibb Maitland, between the Cretaceous and the Blythesdale Braystone.

Mount Playfair and the Dividing Range near Mount Playfair (west of Carnarvon Station) are composed of Bundamba sandstones. The same formation continues in the gorge of Goodliffe Creek on Castlevale Station and on the head waters of the Claude River. The sub-artesian bores in the Warrego Range area at the head of the Nive River show sections which are quite typical of the Walloon horizons, and in several coal has been met with. Hence it would appear that the Walloon belt takes a swing conforming with that of the Dividing Range, and

runs north-north-west from Mount Playfair. The parallelism between the Great Dividing Range and stratigraphical structure has already been commented on and is indeed remarkable.

In the Dividing Range north of Mount Playfair, we have practically the divide between the Bundamba formation on the east and the Walloon on the west. The dip must steepen here as compared with what obtains to the east and south-east, for the formations are compressed into narrow belts west of Mantuan Downs, and soon we lose them altogether under that Cretaceo-Tertiary Desert Sandstone which is the prevailing surface formation at Pine Hill, Alpha, Jericho, and other places on the Central line. It is extremely likely that some of them cut out altogether as we proceeded north along the divide or Cretaceous border. In North Queensland the Bowen beds are immediately followed by Upper Jurassic sandstones, as at the back of Hughenden and in the Gregory Range the Permo-Carboniferous itself is not represented. It appears that the western extension of the Drummond mass cut out at least Ipswich and Bundamba sedimentation in the Dividing Range formations north of Castlevale.

We will now consider the Ipswich, Bowen, and Star formations in some detail, showing their extent, peculiarities, and composition, commencing at the top.

The Ipswich formation is in the Carnarvon area divisible into, first, a thin upper series of beds consisting of conglomerate at the top, then hard silicious shales and conglomerate bands, then ferruginous shales, then below this a fairly thick series of calcareous tuffy shales and sandstones of a dark-green to brown colour; below this a considerable thickness of calcareous shales and unbedded limestones passing downwards into calcareous sandstones and finally yellow felspathic sandstones.

In the Bullaroo Gorge, a tributary of the Moolayamber, the Ipswich Series is best exemplified. Right under the lowest sandstones of the Bundamba in the Carnarvon Range, which are somewhat calcareous, we get a coarse conglomerate 20 ft. thick, which is the passage bed between the Ipswich and Bundamba. Below the conglomerate are white and red hard shales in thin bands containing *Thinnfeldia odontopteroides* and other impressions, also a couple of fossiliferous ironstone bands. These thin beds are intercalated with grits and conglomerates, and the total thickness of the horizon is less than 40 ft. Under this horizon we get the calcareous tuffs, which are 200 ft. or more in thickness. Several beds in these are exceedingly rich in fossil plant stems belonging to species of Schizoneura, Phyllotheca, Neocalamites, and Nœggerathiopsis. In several bands fragments of Thinnfeldia also occurred.

The stems of the Neocalamites type were found to abound to a surprising extent in all shaly and calcareous sandstone horizons of the Upper Bowen and Ipswich Series. They link the two series into one. Both within and below the tuffy horizon were calcareous beds of freshwater origin, judging by the abundance of plant remains in them. The lower calcareous bed yielded great boulders of spheroidally weathering black limestone, which on fractured faces showed joints and crevices in different directions, infilled with crystallised calcite and ferruginous dolomite of an amber to brownish colour.

Below this bed occurs a series of calcareous shales and sandstones of a yellow colour and containing Thinnfeldia fragments. This series on Bullaroo Creek passed down into coarser yellow felspathic sandstones with Thinnfeldia.

At the head of Buckland Creek the higher horizons of the Ipswich Series were capped with basalt. The only horizon showing was that of the lower yellow sandstones. The same plant fragments occur here as on Bullaroo Creek.

On Vandyke and Meteor Creeks the Ipswich Series is completely covered up, but on Spring Creek east of Bullaroo Creek we get the complete series. The top of the series was noticed on the Arcadia fall of Jack's Mountain. The series is well developed between Bedourie and Wallangara Creek, and although no fossils were got here, owing to the comparative flatness of the country traversed on the tableland, the lithological sequence was practically the same as on the Moolayamber, except for the tuffy horizon being inconspicuous. The soil and vegetation also corresponded.

The Ipswich formation, owing to the intercalation of felspathic sandstones and shales with calcic sandstones, shales, and tuffy rocks, yields rich soils, chiefly red heavy loams where the drainage is good, and black soils where the drainage is inferior. On the more calcareous beds we get brigalow-belar scrubs, often long belts and often of the "clump brigalow" description, in which prickly-pear is spreading with alarming rapidity favoured by the high soluble salts content of the soil. The condition par excellence which favours prickly-pear is a high content of hygroscopic moisture in the contained water-soluble matter. This the pear abstracts, and the dehydrated soils re-absorb a fresh supply from the air or by the capillary rise of ground water.

Information was received from station managers, stockmen, and others about all areas which could not be personally visited. The bulk of the Arcadia Valley was left out of the venue, but it was learnt that this valley is mostly brigalow scrub infested with prickly-pear. Lying as it does between the known Ipswich (Series) areas of the Moolayamber and Spring Creeks on the

west and Bedourie on the east, Bundamba sandstones having been proved south of it, and Upper Bowen sandstone north of it, one can safely regard it as Ipswich formation.

Likewise, it was learnt that the brigalow scrub zone of Bedourie stretches east-north-east through Reedy Creek towards Coorada, north of the Bundamba area passed through in Glenhaughton. This is therefore probably Ipswich. Similar brigalow country occurs south of Roper Pass Hills and Ruined Castle Range, in an area known as "The Amphitheatre" at the head of the Robertson River. The river runs underground for three miles under a range, obviously limestone of the Ipswich Series covered with brigalow-wilga scrub.

Another feature of the Ipswich formation, especially the lower sandstones, is the manner in which cane-grass thrives on that formation. We get an abundance of this on the Ipswich formation of Bullaroo Creek and Buckland Creek. On these sandstones the forest trees include molly box (*E. rariflora*), silver-leaf ironbark (*E. melanophloia*) and poplar box (*E. populifolia*).

The Permo-Carboniferous System.

The Upper Bowen Beds.

These can be approximately divided into—

(1) A basal marine series consisting of black friable shales with gypsum crystals on the bedding planes and limestones with a characteristic retinue of fossils including *Martiniopsis subradiata,* crinoid stems, *Strophalosia Clarkii, Zephrentis camodon, Z. robusta, Spirifer tasmaniensis, S. bisulcata, Productus brachythærus, Stenopora tasmaniensis, Murchisonia carinata,* Mourlonia, *Orbipora Waageni,* &c.

(2) Superimposed on the marine series we have a fresh-water series of shales and mudstones with Glossopteris remains in abundance. On Carnarvon Creek Glossopteris and Gangamopteris were found together in a cherty mudstone near the top of this series. A bed of sandstone follows, and this very profuse in petrified logs.

(3) Then follows a series consisting of white and yellow sandstone with intercalated thin beds of shale, coal, and fireclay. Near the head of Carnarvon Creek two coal-seams and one kerosene shale bed occur in close proximity.

(4) Above the coal-bearing series occurs a great thickness of sandstones, beds of which are highly ferruginous and which contain bands of hematite and ferruginous shale.

These four divisions were not represented on each of the creeks in which the Upper Bowens were traversed.

On Buckland Creek about eight or nine miles above Nardoo Station, the banks in the creek showed a thick series of shales with abundant obscure plant remains, chiefly stems. A large dyke of porphyritic andesite here cut the shales vertically, striking north-south magnetic. For four or five miles upstream from these shales the formation is principally sandstone corresponding well to the character of the upper sandstones of the division.

The dips are south-west and south at various angles up to 6 and 7 deg. About twelve miles above Nardoo on Buckland Creek we have yellow sandstones extremely like those on the Moolayamber which are regarded as passage beds between the Ipswich and Upper Bowen. Here plant remains abound, and, although they were obscure, there were fragments which closely resembled Cladophlebis and Thinnfeldia associated with stems of Schizoneura, Neocalamites, &c.

From the narrowness of the upper sandstone belt and the absence of steep dips, it is concluded that the upper sandstones thin out in a westerly direction.

Now, below the shales outcropping nine miles or so above Nardoo, we have again sandstone of a yellow and white colour for a few miles. In one bank about six miles from Nardoo these sandstones are seen to take a sharp tilt, dipping south at 30 deg. Near this point was noticed a small conical mound consisting largely of impure gypsum. Two well-marked parallel bands in the tilted sandstones were suggestive of overthrust faulting, but an examination of the cliff failed to give any corroborative evidence. Under the sandstone we seem to get quite conformably intercalated beds of Glossopteris-bearing mudstone (like that on Vandyke Creek) and black thin-bedded shales. The latter contain at least one band of highly carbonaceous shale or dirty coal about 4 ft. in thickness, the decomposition of which has coated the exposed outcrop with alum and sulphur encrustations.

About half-a-mile lower down the creek where the creek enters brigalow scrub and leaves the hills, a boulder of shell rock was found, which it is concluded must have come out of the formation under the carbonaceous shales. The fossils present were Martiniopsis. Other limestone boulders were cracked, and though obviously from the same bed contained no fossils. From this point to Nardoo, about five miles only, blacksoil country with brigalow was seen. This area is probably all limestone and calcareous shale of the marine division of the Upper Bowen. Mr. Morgan, the manager of Nardoo, gave interesting information on the nature of some of the surrounding country which deserves quotation:—

"At Lake Salvator the country is all sandstone. The lake is only a large swamp.

"Due south of Nardoo at Point Rangeland the high basaltic tablelands on the Dividing Range end, and the range becomes a mere sandstone divide with isolated basalt cappings.

"A great abundance of petrified wood occurs on Mantuan Downs."

(Compare the abundance of petrified wood in places in the Upper Bowen, as near the coal measures on Carnarvon Creek, and in the Ipswich formation from which petrified wood has been shed in Buckland Creek; the Moolayamber, and on Bedourie.)

"Red agate is very abundant in a basalt ridge five miles west of Nardoo.

"Mantuan Downs is flat plains and brigalow plains with black soil. The bores are sub-artesian, fairly deep and all poor, scarcely in any instance yielding 500 gallons per hour continuous pumping. The average depth is 300 ft. Under the blue shale (Upper Bowen limestone ?) the bores find a sandstone formation.

"Red banks are a feature of Buckland Creek below Nardoo Station."

The significance of this feature lies in the fact that under the Upper Bowen limestone lies the "Tumbledown" formation of interbedded yellow sandstones and red clays which yields similar red banks on Yellowberry Creek, Morella Creek, and elsewhere.

From these remarks it is clear that most of Mantuan Downs belongs to the Upper Bowen marine beds and coal measures.

The formation three miles north-east of Nardoo is sandstone, the upper sandstone. The bore at the junction of Buckland and Wharton Creeks passes through 300 ft. of sandstone, which, however, is probably the sandstone of the Tumbledown series of the Middle Bowens.

From Nardoo the route taken was north-east to Blue Hills or Colliblue, where a group of detached basalt hills are found lying on Middle Bowen sandstone. For the first four miles from Nardoo the vegetation was typically calciphile—brigalow, wilga, sandalwood, bauhinia, &c.—indicating the marine limestone beds. For the next two miles calcareous sandstone, probably still marine, predominated. From six to twelve miles from Nardoo, travelling east, the country was composed of Middle Bowen sandstones and conglomerates which will be described later; but about twelve miles from Nardoo, at the bore lying between Blue Hills and Mount Sunday on portion 2, parish of Sterculia, we again met with black soils, brigalow country, and every indication of the marine formation except the actual outcrop. From this bore we travelled north through formations which will be referred to later.

A return to the Upper Bowen formation was made in the traverse up Vandyke Creek. At "The Rocks" east of Mount Sunday, where the Big Vandyke and the Little Vandyke and Sunday Creeks join, there is a spring and permanent waterholes in a white and yellow sandstone (silicious and felspathic beds alternating) with ferruginous seams, on Wealwandangie holding. This sandstone is undoubtedly the upper sandstone of the Tumbledown formation. It resembles the sandstones on Yellowberry Creek and Morella Creek of that age. Below these sandstones the creek (Vandyke) runs through gently undulating country with low sandstone mesas, the creek showing red banks in places, crumbling shales and yellow sandstones in other places. The sandstones of The Rocks are capped with coarse boulder beds, perhaps tertiary glacials, perhaps creek-wash, and over the boulder bed lies a basalt sheet. The basalt is later than the period of boulder deposition. The boulders constitute a typical quartzite "billy." The altitude of The Rocks is about 1,250 ft. above sea-level. Some of the sandstones contain fragments of Calamites, Neocalamites, and Schizoneura. The dip is very gently to the south-south-west. Right at the top of the sandstone near the biggest waterhole at The Rocks and under the boulder bed we see the shales just appearing a few feet in thickness. These are the base of the Marine Upper Bowen. This formation extends west round the base of the basaltic peak, Mount Sunday, and east-north-east over the divide between Spring Creek and Vandyke Creek about four miles north of the basalt-capped Mount Sterculia (1,400 ft. high). It should be mentioned that the basalt of Sterculia and surrounding spurs and ranges lies on a peneplain averaging 1,000 ft. high.[1] This peneplain falls gently to the north and east in this vicinity until near the Nogoa it commences again to rise towards the Drummond Range. In the writer's opinion this represents the level of a wide, smooth valley which once existed between the Carnarvon cliffs (the 2,400-ft. level) and the Drummond Range, when the drainage from Mantuan Downs went into the Comet instead of the Nogoa. The basalt flows changed all this.

Under the Mount Sterculia basalt, the sandstone is of the Tumbledown formation. South of Mount Sterculia, on the range between Spring Creek and Vandyke, there is an abundance of petrified wood near the border between the sandstone and the marine.

Proceeding up Vandyke Creek from The Rocks, we come in less than two miles to a thick series of shales, chiefly black with fragmentary plant remains. Intercalated are thick bands of mudstone with beautifully preserved Glossopteris, also carbonaceous shales. The dip continues south at 3½ to 5 deg. This formation continues for two miles. Then we get sandstones, fireclays, and shales, mostly white sandstone, for another two miles. In this formation there must be coal-seams, for

fragments of coal were picked up in the creek here, but the creek was so rough that it could not be followed continuously and the actual coal outcrop was not seen. The coal was similar to the Carnarvon coal. Above the coal measures ferruginous sandstones set in, which are now regarded as the commencement of the upper sandstones. Here, however, the basalt came right down on to the creek level, and a study of the creek to the Ipswich formation was consequently impossible.

From Vandyke Creek we crossed over to Spring Creek, following approximately the northern boundary of the Tumbledown formation, but striking south-easterly to descend the range the marine beds were again entered with their brigalow scrub and blacksoil plains. In the Vandyke-Spring Creek divide, Mr. Slatyer, manager of Wealwandangie, has obtained specimens of beautifully crinoidal limestone. This fossil locality was, however, missed by the writer, who kept too far to the north under Mount Stereulia.

The type of country indicative of Marine Bowen continued to Wealwandangie striking approximately east-north-east, interrupted of course by occasional stretches of basalt capping.

Three and a-half miles west of Wealwandangie there is a hill capped with shaly sandstones and rendered cherty by a former basalt covering. The eastern slope of this hill exposed the underlying marine limestone, which contained a wonderful mixture of well-preserved fossils. This limestone again overlies black shales of marine origin which have selenite crystals on the cleavage planes. These are well represented at Wealwandangie near the station in the banks of Cona Creek. The dip here is very gentle to the south-south-west.

As far as one can judge, the fossiliferous limestone bed is probably not more than 20 ft. in thickness, while the underlying marine shales and the overlying calcareous sandstones of the same series are several hundred feet thick. The fossiliferous horizon has nowhere yielded a strong outcrop, although specimens of it have now been found on Buckland Creek, Vandyke Creek, Wealwandangie, and Consuelo Creek (Black Alley Peak).

Mr. Smith, of Springsure, stated that he had seen two large coal-seams up Cona Creek in Goatlands. This is quite probable. They would be equivalent to the Carnarvon Creek seams.

Freitag Creek was found to have in its bed typical coal measure sandstones and shales above McLaughlin's place west of Dingo Hill. The dip was puzzling, being gently to the south. The formation here is the same as that met with above the marine on Buckland and Vandyke Creeks. Freitag Creek has the basalt encroaching close to its banks on both sides and was therefore not suited for comparative study. The sergeant of

police at Springsure kindly informed me that, when hunting on Freitag Creek for a murderer after the earthquake of 1917 (?), he came across a huge freshly opened fissure. He also saw sea-shells (marine fossils) in places. The fissure is interesting in being possibly a reopening of the great fault (the Freitag Fault) which runs along the west side of the Sericold Anticline. The earthquake mentioned was felt very severely at Rewan police station, where a two-roomed building was shifted on the stumps several inches from south-east to north-west, indicating an earth movement towards the south-east. This may be a pulse of the same kind which caused the uplift of the Drummond Range and the Sericold Anticline.

The next place where Upper Bowen marine rocks were encountered was two miles east of Black Alley Mountain, about six miles west of Rewan. Here they were found lying unconformably on a buried pinnacle of ancient formation. The fossils secured were crinoids, corals, and brachiopods. Close to this locality two brothers named Turvey found Permo-Carboniferous fossils in 1919-20 while shooting there.

Lying on the top of the fossiliferous horizon there are several hundred feet of friable felspathic calcareous sandstone. The dip of these sandstones is 5 deg. on 235 deg. About a mile east of Black Alley Peak, the dip increases to 30 deg. in a southerly direction, but this was a local steepening, although for a considerable distance a west-south-west dip on 25 deg. was observed. The upper beds of sandstone near the mountain become more barren and silicious, the dip flattens, and there is an abundance of petrified wood scattered about which suggests the same bed as is met with near the coal-seams on the Carnarvon Creek. The Sericold fault probably accounts for the steep dips east of Black Alley Peak (Section). This peak is capped with basalt and probably has also a plug or core of basalt. The height is probably about 2,600 ft., the last 300 ft. of which is volcanic. Consuelo Peak (or Tableland), probably 3,500 ft. high, also is capped with basalt overlying sandstones which are probably the upper sandstones of the Upper Bowen. The sandstones of Black Alley Peak and thence to Consuelo Creek contain alternating beds of shale with Glossopteris, and probably coal-seams will be found here. The forest flora on these sandstones consists of spotted gum, silver-leaf ironbark, narrow-leaf ironbark, common wattle (*Acacia Cunninghamii*), silver wattle, apple, and river gum with an abundance of zamia.

The Upper Bowen formation is again met with on Carnarvon Creek on Wells's block, portion 2, parish Aubrey. In a bank on the creek we have black shales weathering to brown clay, which is suggestive of the Wealwandangie marine shales. The fossiliferous limestone is not seen. The dip was to the south-west at 7 deg. About a mile south of this we pass on to calcareous sandstones and mudstones on which Glossopteris

and Gangamopteris were found together in a cherty shale. The sandstone contains an abundance of fossil trees. Another mile or so further south, the sandstones become more silicious, and, in examining a gully known in these parts for a coal-seam which was on fire for four years, the writer found yet another coal-seam and two kerosene shale beds. These mineral occurrences are in a sharp gully running west into Carnarvon Creek near the south-west boundary of portion 2. South of the junction lies a little basalt plug. A few miles to the west we see sandstone cliffs forming a continuous line of escarpments capped with basalt. In character they suggest Bundamba sandstone, and they show a tendency to dip either north-west or south-west into the foundations of the nearest heavy mass of basalt. These cliffs are the northern (and north-eastern) face of the Dividing Range at the back of Mount Moffatt Station. Near Mount Moffatt a spring was found from which bubbled a great stream of inflammable gas.

The lower part of the coal gully on Wells's property (Carnarvon Creek) is in yellowish sandstones with intercalated black and white shales. These dip very regularly to the south-east at 7 deg. The lower coal-seam is between 4 and 5 ft. thick, a very clean coal, not a band visible. The quality of the coal is similar to the upper coal. The upper coal-seam shows 4 ft. of clean coal, but is much thicker. There appears to be a band and then another 4 or 6 ft. of coal which was somewhat obscured by mud in the bed of the creek. This seam was 55 yds. higher up the creek than the first (lower) seam, equivalent to 20 ft. in vertical distance on the level, but as the ground in the interval had fallen another 20 ft. the seams are probably 40 ft. apart. About 55 yds. higher up the gully, and fully 40 ft. higher in elevation, occurs a seam of kerosene shale 3 ft. in thickness and separated by a 6-in. band from an underlying 6 in. of kerosene shale. The vertical height of the shale above the upper coal (formerly "burning") seam is about 60 ft. Another 6-in. seam of kerosene shale was found about 50 yds. higher, near the hill summit. These coals and kerosene shales are separated by yellowish sandstone and white sandstone. Each has a thin ironstone roof.

On the right bank of the gully was seen the trace of a small east-west fault, all the seams being seen south of the fault. It is extremely probable that a huge fault lies approximately along the north-south course of Carnarvon Creek, west of Wells's (portion 2), this accounting for the vanishing of the Ipswich formation here between the Upper Bowen and Bundamba. The fault is the continuation of the Freitag fault.

The Upper Bowen coal formation runs through the west end of the Morella Range, along the Morella Creek and Moolayamber valleys through the Lake Nuga region, thence north-east to Clematis Creek between Purbrook and the Gorge

A fragment of coal was found on Bullaroo Creek, but it was so small that possibly it was just a carbonised fragment of wood out of the Ipswich Series, or perhaps out of the Bundambas. The marine formation was not seen on Carnarvon Creek except so far as indicated by the shales in the north-east corner of portion 2, but it is indicated by the belt of brigalow-belar-wilga scrub which from Carnarvon Creek between portions 3 and 4 (parish Aubrey) passes east to the Morella Range, crosses that range, and turns along the south side of the Moolayamber to Warrinilla head station, thence past the south shores of the Lake Nuga, where it turns almost north to Lake Brown to the east of the ranges through which the Brown River runs.

The upper sandstones of the Bowen formation are well developed at the head of the Moolayamber, at the junction of the Moolayamber and Bullaroo Creek, and in the Clematis Gorge. The middle beds of the upper sandstones are highly manganiferous, the manganese being evenly disseminated and giving the rock a brown colour.

At Warrinilla Station small fragments of kerosene shale were found in Carnarvon Creek, but the banks were so covered with flood-silts that all hope of finding exposures was abandoned. The marine and coal-bearing horizons of the Upper Bowen are remarkable for the abundance of salt-seeking plants—saltbush, couch grasses, brigalows, &c.—and for salt being unnecessary for stock on these belts.

Fossils of the Lower Bowen Marine age have been collected by Mr. A. L. Peart, surveyor, on the Dawson River survey in connection with the Dawson irrigation scheme; these fossils include spirifers, Mourlonia, crinoids, *Murchisonia carinata*, Productus, *Zaphrentis Gregoriana*, cyathophylloid corals, &c.

Such enormous quantities of river silt fill the lower reaches of the Moolayamber, Carnarvon Creek, Clematis Creek, &c., that in these areas no exposures and no fossils were obtained. The vegetation, soil, and the location of the Tumbledown formation which underlies and the upper sandstone which overlies the marine and coal measures were the only criteria for fixing the position of these belts along the Moolayamber and on Warrinilla.

The Upper Bowen upper sandstones are very disturbed in the Moolayamber region near the junction of Bullaroo Creek, taking a very sharp tilt at 45 deg. in one place, but the dip soon falls again to about 10 deg. as in Upper Bullaroo Creek. Owing to this high dip, these sandstones outcrop only for a width of two or three miles on the Moolayamber, while on Clematis Creek the belt is at least eight miles wide.

The thickness of the Upper Bowen, calculated on the observed dip of 3½ deg. on Vandyke Creek, gives—

	Ft.	
Tumbledown formation (underlying Upper Bowen)	1,212	
Marine Upper Bowen	453	1,659 ft.
Freshwater shales and mudstones with Glossopteris	606	
Coal-bearing sandstones	600	

Calculated on the observed dip of 7 deg. in the Morella Range and 5 deg. on the Moolayamber before reaching the steep dips in the upper sandstones, we get—

	Ft.
Tumbledown series (Middle Bowen)	1,296
Marine, freshwater, and coal series	1,847

The upper sandstones overlying the coal measures, calculated on a dip averaging 3 deg. in the Clematis Gorge, have a thickness of 2,213 ft.

The Ipswich formation, calculated on its observed dip of 10 deg. in the Bullaroo Gorge, has a thickness of about 4,000 ft. The lower sandstones represent about half of this thickness.

We have therefore, in the Ipswich and Upper Bowen—

	Ft.
Ipswich shales, tuffy shales, limestones, sandstones ..	2,000
Upper Bowen sandstone (shingly sandstones) ..	2,200
Coal measure sandstones	600
Glossopteris shales and mudstones	600
Marine beds	450
And below that the Tumbledown series of the Middle Bowen	1,300

As the analysis of the Middle and Lower Bowen proceeds the thicknesses of the horizon will be similarly calculated.

The Middle Bowen Formation.

The Middle Bowen Series included the following formations from above downwards:—

(1) The Tumbledown formation;
(2) The upper sandstone—largely red sandstones;
(3) The coal measures;
(4) The lower sandstone.

(1) The Tumbledown formation is only separable from the upper sandstone in areas near the headwaters of the creeks, where the country is undulating and hilly. Its thickness, as already shown, is between 1,200 and 1,300 ft. It consists of alternating beds of yellow sandstone and red clay, the latter presumably a decomposition product of shale. The clays fret away and the sandstone beds collapse. This formation is well developed in the Morella Range south of Rewan. We see it also at a remarkable cirque, a depression with cliff-like walls, called "The Crater," in the Rewan paddock near Morella Range. This crater is about 30 ft. deep, covers an area of between 10

and 20 acres, is quite flat on the bottom, so that it could be used as a sportsground with the spectators lining the lip of the depression. Reddish clays here underlie a yellow sandstone, and the crater is constantly enlarging by the sandstones tumbling down as the subjacent clays are weathered away. A small gorge drains the crater. In the crater were found innumerable bone fragments identified by Mr. H. A. Longman, Curator, Queensland Museum, as reptilian, belonging to an extinct species of Crocodilia. There is no direct evidence in favour of either the theory that the crater originated in the burning out of a coal-seam or that there has been leaching and undermining through soluble limestone beneath. Indeed, the evidence points to a slight dome existing here in the stratification, and, a gully having worked into the soft clays under the sandstone of the apex, the cirque has been formed by undercutting.

There are two other red-clay horizons very similar to those of the Tumbledown series. One underlies the upper sandstones of the Upper Bowen, but it is not extensive. Another lies in the upper sandstones of the Middle Bowen, and may be seen in Carnarvon Creek crossing two miles south of Rewan Station.

(2) The upper sandstones of the Middle Bowen are a formation composed chiefly of silicious sandstones and red ferruginous sandstones. The upper beds are particularly silicious, and have swampy tracts on the surface where they occur on flat country. A few beds of red clay from shales occur in the series.

The vegetation on this formation comprises Moreton Bay ash (*E. tesselaris*), sugar-gum (*Angophora lanceolata*), swamp mahogany (*Tristania suaveolens*), wattle (*Acacia Cunninghamii*), spotted gum (*E. maculata*), bloodwood (*E. terminalis*), crooked or "tumbledown" gum (*E. dealbata*), and on hills also yellow bloodwood (*E. trachyphloia*), stringybark (E. sp. uncert.), boodgeroo (Lysicarpus sp.), woolly oak (*Casuarina inophloia*); and in fact the same retinue of timbers as on the Bundamba formation, though the associated red beds and red sandstones favour ironbark (silver-leaf, narrow-leaf, and gumtop—*E. melanophloia, E. crebra,* and *E. siderophloia* var.). Where the soil is a very silicious sand and the situation is hilly, we also get pine scrubs on this formation. There is also grass-tree (*Xanthorrhœa*) in swampy parts.

The formation is well represented down Yellowberry Creek south of portion 4, parish Yarrai—i.e., in the parish Sterculia. It extends east-north-east through portion 16, parish Cona, and thence in the same direction till it vanishes under basalts south of Springsure. The sandstones of The Staircase, south-east of Springsure, are probably the same formation. We do not recognise the formation again, owing to the prevalence of basalt cappings on Meteor Downs, Albinia, &c., until we get it north of Consuelo Station on Peawaddy Creek; it overlies the coal

series on Mount Inglis under the basalt and comes down again on to Peawaddy Creek near Sugarloaf Mountain. It runs south along the eastern side of Consuelo Valley forming a range. We have this formation south of Rewan. The strike changes to north-east here, and probably the formation is met with pretty continuously through the hilly country stretching from Rewan to the Comet River in the parish Vesta.

(3) The Middle Bowen coal measures are obscured in most regions owing to the ready disintegration of the felspathic sandstones, shales, calcareous beds, and carbonaceous beds of which they are composed. The soils are fair and the timbers seen on the series consist principally of bloodwood (*E. terminalis*), silver-leaf ironbark (*E. melanophloia*), gum (*E. rostrata*), box (*E. populifolia*), with sandalwood (*Eremophila Mitchelli*), &c.

This formation is evidenced by soil and timbers on portion 4, parish Yarrai, Yellowberry Creek, where we also get exposures showing shales, felspathic sandstones, and limestone (no fossils) intercalated. No coals were seen here, but the exposures are probably covered up. We meet the series on Vandyke Creek on portions 8 and 15, parish Cona. They occur again probably in the wells on Cairdbeign, south of Springsure, in which coal was obtained; and they occur along the Consuelo Valley. They have not been traced further, but this series probably underlies Rolleston and Planet Downs, and may continue across the Expedition Range and merge into the lower coal measures of the Dawson River.

(4) The lower sandstones of the Middle Bowen are silicious and conglomeratic, with intercalated ferruginous strata. The vegetation is in general calciphobe, including Moreton Bay ash (*E. tesselaris, E. papuana*), yellow bloodwood (*E. trachyphloia* and *E. Watsoniana*), pine (*Callitris calcarata*), an abundance of wattles of different species, spotted gum, lemon-scented (*E. maculata* var. *citriodora*), boodgeroo, some stringybark, some lancewood, some woolly oak. It is poor country, yet it is grassed much better than the Bundamba sandstones. Pebbly conglomerate beds, many of great thickness (up to 100 ft. noted), are characteristic of the series.

The series was met with on Yellowberry Creek, portion 5, parish Yarrai; on Vandyke Creek, portions 7 and 8, parish Cona; on Meteor and Sandy Creeks, parish Albinia; on Peawaddy Creek, north-west of Consuelo Station, &c. It was seen high up in the Black Alley Range around Mount Sericold, and around the eastern edge of the metamorphic outlier east of Black Alley Peak.

In the traverse down Yellowberry Creek the upper sandstones of the Upper Bowen Series were crossed from the bore on portion 2, parish Sterculia, for seven miles north. It was impossible to distinguish the Tumbledown formation as a separate entity. Red Sandstone hills (mesas) formed a feature

of the topography. The coal measure belt was then traversed for five miles, giving better country with shales, sandstones, and clays alternating. A limestone bed also was evidenced. Some volcanic trachyte occurs here, four miles north of Hillview (Sypher's place), but may be of Tertiary age.

The average dip in the upper sandstone was south-west at 3 deg., changing to south at 3 deg., which was dominant from the bore to Sypher's. North of this the dip was south-south-east on 4 deg.

The lower conglomeratic sandstones were followed eight miles on an average dip of 5 deg. in the line of section to within a mile of the Nogoa banks.

On Vandyke Creek the Tumbledown and Middle Bowen upper sandstone outcrop for five miles on an average dip of 2½ to 3 deg. to the south, the coal measure series dip about 4 deg. for a mile or so, but at one point the strata take a sudden lurch to the south at a high angle. The lower conglomeratic formation outcrops for eight miles with an average dip of 5 deg.

The series is incomplete on the Meteor-Consuelo side. The strata are highly tilted in the Mount Sericold Range, and, being too variable, unsuited for the use of the dip in determining the thickness. The Consuelo Valley has coal measure formations outcropping for a width of about two miles with an average dip of 10 deg. The dip steepens to the west and flattens to the east.

Between the Tumbledown series on Rewan and the coal measure belt is a distance of about five miles, representing sandstones with an average dip south of 5 deg. Rewan itself is taken to be situated on the coal measures. The dips along Yellowberry Creek, Vandyke Creek, Consuelo Creek, and Rewan give the following approximate thickness of each of these measures:—

MIDDLE BOWEN FORMATIONS.

	Tumbledown.	Upper Sandstone.	Coal Measures.	Lower Sandstone (Conglomerate).
	Ft.	Ft.	Ft.	Ft.
Yellowberry	..	About 2,000	1,800	6,000
Vandyke	..	About 1,800	..	6,000
Consuelo	..	..	1,800	..
Rwaen	1,300	2,275	..	..

The total thickness of the strata above the coal measures seems to be 3,600 ft. south of Rewan as compared with 1,800 ft. on Vandyke and Yellowberry Creeks, but as the dips are low and only estimated, and as faults or local steepenings of dip may have been missed, the real thickness may approximate closer for the two regions. It is also possible that the upper beds thin out considerably in the western area. The total thickness of the Middle Bowen series is not much under 10,000 ft.

The Lower Bowen.

The Lower Bowen formation was met with principally along the Nogoa River between Nandowrie, Needle, and Vandyke Creeks. It was seen outcropping seven miles north of Springsure at Dilly, and coarse conglomerates considered to be Lower Bowen were seen in the distance in the Mount Sericold Range, tilted at high angles by a local violent uplift probably coeval with the volcanic eruptions.

The best idea of the composition of the Lower Bowen beds can be obtained along the Nogoa.

After leaving the Middle Bowen near Nandowrie-Needle, one passes on to a blacksoil plain which is probably of limestone formation. There are patches of brigalow scrub. The next formation met with on portion 3, parish Yarrai, is calcareous sandstone with sandy loam soil on which we get bauhinia and other calciphile vegetation. This lasts for a mile and a half. The dip, as evidenced by the bedding planes in the hills in the distance, is south-west at angles ranging from 5 to 10 deg.

Next we find, pursuing a north-east course, a conglomerate giving a boulder surface in which cherts, jaspers, and quartzites abound. This boulder country continues about a mile. We then get on to black soil and soon meet with basalt and amygdaloidal rhyolite, chertified tuff, and other volcanic rock. Whether this is of Bowen age or Tertiary is not quite clear, but the condition of the rock points to its being an interbedded volcanic series. On leaving this formation we again get on to a very thick formation of conglomerate, a great portion of which consists of large boulders. The dip here is south at 10 deg. This passes downward into grit and sandstone. This boulder country and the sandstones have a calciphobe vegetation, in which pine and ironbark play as important a part as bauhinia, coolibah, and box in the good volcanic and calcareous soils of the belts aforementioned.

Under the sandstone belt on 6v, Uranna, we have a rather remarkable contorted formation looking like a contorted shale, which is probably a varve shale. It only shows for a short distance.

Very soon, still on 6v, we pass on to a boulder formation also consisting of huge boulders, which seems to lie on soft arenaceous clay or till. Coolibah and brigalow grow on this formation, and it seems to be a Tertiary glacial till and conglomerate. This continues nearly to Vandyke Creek. In the bed of Vandyke Creek we get a sandstone with beds of greenish shale dipping in a variable manner. This formation is not unlike the upper beds of the Star series, but it is more probably a reappearance of the varve shale series. On Kavanagh's property east of Vandyke the massive boulder conglomerates again appear, but dip east and south-east. The average dip is east at 15 deg. Vandyke Creek occupies approximately the axis of an anticline.

At the junction of Norwood and Vandyke Creeks, the dip is south-east at 17 deg. in the upper of the two big Lower Bowen conglomerates.

The average thickness of the whole Lower Bowen Series, including the top limestone, the upper glacial, the volcanic, and the lower glacial beds, but not including the varve shale. is about 7,300 ft.

Proceeding up Vandyke Creek the dip was mostly south-east, and the formations met with along the Nogoa were seen again excepting the upper limestone, which must be covered up with alluvium on portion 7, parish Cona.

The limestones of this series were seen at Dilly, seven miles north of Springsure, and yielded a number of fossils, including *Protoretepora ampla, Eurydesma cordata, Stenopora Jackii,* S. sp., Polypora sp., *Strophalosia Clarkii, Productus brachythærus, P. subquadratus, Platyschisma oculus, Deltopecten illawarensis, Fenestella internata, F. fossiola,* Zaphrentis sp.

It should be here mentioned that some doubt exists in the mind of the writer whether the trachytes and basal andesitic basalts of Springsure should not be regarded as Lower Bowen.

The flows of the lower lavas and the tuff beds have a general slope to the south closely approximately to the dip of the beds.

There is no doubt that the top basalts of Springsure are Tertiary, but the andesitic basalts present many features suggestive of greater age, as do also the trachytes.

The Star Series.

The Star Series form the basal members of a great thickness of strata between Bogantungan and Mitchell which show little folding.

Mr. Geologist Saint-Smith and the writer spent a few days at Bogantungan and Hannam's Gap to get conversant with the typical Drummond Series. The writer subsequently went to Alpha to inspect the extent of the series.

It was found that the Drummond (Star) Series consists of a thick sandstone formation with lepidodendron and an overlying calcareous shale formation carrying fish remains. The Drummond Series is folded irregularly into domes and synclines, but the dips were usually gentle not exceeding 15 deg., except one and a-half miles west of Drummond, where a dip close to 45 deg. was observed in a railway cutting.

Inclusions in the lepidodendron series and wash in the streams heading in the Drummond Range point to porphyrites and diabases lying at the base of the series.

The thickness could not be calculated owing to the variable dips and undulating folds. It is, however, probable that the upper shales contain several thousand feet of strata and the lower sandstones no less. The whole of the Drummond Series shows more induration than noted in any of the Bowen Series.

Members of the Drummond shale series were noticed outcropping near Gindie on the Springsure-Emerald line, but the outcrops are few, basalt being the prevailing formation. A few miles south of this, near Fernlees, rocks of the Lower Bowen were met with. North of Gindie one sees little but brigalow scrub till one gets near Emerald, when old diabases (basalts) show up. These no doubt belong to the Drummond Series.

Lepidodendron occurs abundantly at Mount Beaufort south of Pine Hill, showing the presence here of Lower Star rocks.

The diabases at Emerald closely resemble those in the Fitzroy River at Rockhampton.

There is no doubt that the Star rocks have undergone more folding and induration than any of the Bowen Series. The Bowen beds were probably deposited unconformably on them.

At Pine Hill we find rocks of Desert Sandstone age overlapping the Star, and from Pine Hill to Alpha this formation seems to form a continuous surface capping. The bores (subartesian) put down into the Star beds yield very poor supplies or no water at all. The Pine Hill bores are very poor in supply. At Alpha fair supplies are got in the Cretaceo-Tertiary drifts at about 150 ft., and in the district some of the bores put down have struck coal. It is problematical whether the coal here struck is the Cretaceo-Tertiary Winton coal or coal belonging to the Middle or Upper Bowen coal series.

If the steep dip of the Drummond Series to the south and south-west at Drummond continues into the overlying Bowen beds, the whole of the formations between the Star and the Mesozoic would have their outcrops compressed into about twelve miles. Although a continuation of a dip of 45 deg. is unlikely, it is probable that west of the Drummond upheaval the dips continue steep enough for a long way under the Desert Sandstone to bring Upper Bowen or even Walloon rocks in under the upper drifts and Desert Sandstone at Alpha.

The Anakie Series.

Under this head it has been found convenient to group all the rocks older than the Star Series, including schists, slates, serpentines, quartzites, porphyrites, greenstones, greenstone diabases, quartz, granite, gneiss, aplite, &c.

Boulders of all these rock types occur in profusion in all the boulder beds of the Lower Bowen. Quartzites and cherts

exceed all others in abundance. In the Middle Bowen conglomerates we find fragments of all the above in all the area enveloping the Anakie region, but in the Bowen beds remote from the outcrops of the Anakie Series it is practically only quartz, chert, and quartzite with an occasional porphyry pebble that constitute the conglomerates.

The profusion of the same types of quartzite and chert in all the Tertiary boulder beds from the Springsure district to Mount Hutton leads the writer to consider that the Anakie region was the centre of origin of the glaciers and floating bergs which have spread far and wide the boulder mounds referred to, but in the regions remote from the Anakie district cherts and quartzites of later age are freely intermixed with the older material.

The writer has not personally studied the Anakie region. Mr. Dunstan's investigations, however, show that remarkable boulder drifts are a feature of the region. He has advanced a theory to account for their origin, but the problem is still in the theory stage and the solution must await further evidence. It is not an Anakie problem or a South Queensland problem: it is an Australian problem.

The areas of Anakie and Star formation in the area discussed by the writer comprise—

(1) The southern edge of the Anakie mass itself, which the writer has not seen. It lies close to Anakie. Both Emerald and Bogantungan, which have been cursorily examined by the writer, belong to the Star beds.

(2) A mass of formation in the Snake Range east of Echo Hills, west of Telemon, situated about thirty-two miles south of the railway at Withersfield. This area has not been visited by the writer, but he has been shown copper ore from there, and has been informed from several sources that both granite and mica schist occur there.

West of this mass the Drummond Series reigns supreme. One constantly hears of "fossil snakes" (lepidodendron) picked up here, from Echo Hills to Mount Beaufort.

(3) A small area south of Black Alley Range and east of Black Alley Peak where the writer saw mica schist, granite, aplite, porphyry, quartz (reef material), and country with every appearance of gold-bearing or gem-bearing country. This little area has never been prospected, and is well worth an examination by prospectors for metallic minerals and gems.

(4) A small area of auriferous country is reputed to exist east of Planet Downs in the Expedition Range. The writer has not seen it, but an old prospector, Mr. Penny, informs the writer that he and a mate obtained gold here at the time of the Croydon rush, and that there are granite and mica schist in the area.

(5) A small area of serpentine carrying asbestos exists north of Eddystone Vale. It is also stated that a small auriferous granite area exists on one of the head waters of the Warrego. The probability of this is enhanced by the fact that palæozoic schists were struck at about 2,000 ft. in the Morven bore. East of Tambo near the source of the Nive occurs a small outcrop of diorite slate and quartz.

There can be little doubt that all the areas mentioned except the first are merely pinnacles on a buried ridge of palæozoic rock. Such a ridge probably exists between Morven and Eddystone Vale. Another forms a buried continuation of the Anakie mass in a south-south-east direction under Springsure and along the anticline of Meteor and Mount Sericold.

Buried ridges of this description serve as barriers against subsequent fold movements. Lateral expansion forces the lower sediments to expand upwards against the flanks of these ridges, and the overlying sediments become domed up over the buried ridges and often faulted. Every new fold movement accentuates the doming and fracturing over such structures. They become an important matter of careful study in oil-geology.

Tertiary Deposits.

Tertiary rocks have been left to the last because they are not a strong feature of the area under discussion.

As already mentioned, there are between Pine Hill and Alpha on the Central Railway extensive tracts of sand-rock, interspersed with alluvials, which are regarded as Cretaceo-Tertiary, or Desert Sandstone. In character this rock is similar to the sandstone ascribed to the same formation at Morven, Amby, and other places. It is a variable formation, here a mudstone, there a sandstone, now and again a grit or conglomerate; the variation may be in part due to the derivation of much of this rock from the breaking down of the subjacent formations under meteoric influences, in part to a variable sweep of flood-waters at the time of its deposition. The rock does not give one the impression of being a marine or lacustrine deposit. One gets the impression that it has been laid down on land under peculiar conditions.

It is unfortunately impossible at present to say what formations occur under this rock west of the Drummond Series. It would be interesting to know, but it cannot be judged on

present evidence, whether the coal met with in bores in the Alpha district is of the Winton (Cretaceo-Tertiary) Series, Bowen, or Walloon. The Cretaceo-Tertiary strata thicken in a direction south-east from Alpha, as shown by the sections of the Eastbourne, Lowdon, and Doyle's bores and Bailey's bores, all in the region between Alpha and Tambo. In the Eastbourne bore and Doyle's No. 1, brown kerosene shale is mentioned as having been passed through. This is probably, like the Boyne Valley shale, Cretaceo-Tertiary.

A close watch on the strata drilled through in future boring operations in this area would give useful information.

The "billy" or boulder heaps of Cretaceo-Tertiary age are widely scattered over the whole region from the Nogoa and Consuelo valleys to Mitchell and Roma, but it is a very noticeable fact that they are seldom met with south of the Dividing Range at an altitude of over 1,350 or 1,400 ft., or north of the Dividing Range at an altitude of over 1,000 ft., though on Vandyke Creek they crept up to 1,200 ft. underlying basalt.

They are certainly in the main pre-basaltic, and for reasons already stated the writer concurs with Mr. Dunstan's view that they are derived from a variety of rocks in which surface silicification has gone on. This has probably, in the writer's opinion, been in operation during arid cycles, and the remarkable distribution of the boulders as well as their polish and shape suggest iceberg carriage.

Probably the most important division of the Tertiary formations is the Volcanics, but they are most conveniently dealt with elsewhere.

The Post-Tertiary is represented chiefly by enormous thicknesses of soil especially north of the volcanic areas, and attaining maximum development along the valleys of the Carnarvon and Moolayamber Creeks, the Brown River, Lower Clematis Creek, and environment.

Soils 40 to 50 ft. in thickness are of common occurrence for miles and miles along these streams. The soil is of excellent tilth and great richness, containing silt from basalts, sandstones, calcareous shales, and coal measure formations admirably commingled by past flood-waters. Wonderful belts of deep rich soil also exist along Vandyke, Meteor, and other creeks. When settlement proceeds and railway communication with Rolleston is established there will be no richer agricultural district in the State.

The Volcanics.

The present investigation being primarily intended to solve stratigraphical problems, to investigate mineral resources and probably oil-bearing horizons, the volcanic rocks were not given the study they would seem from their areal distribution to deserve.

They are of little economic importance except in this respect: that their disintegration supplies the rivers and creeks with basalt silt which enriches the alluvial soils for scores of miles below the actual basalt.

Of useful minerals they seem to contain nothing except sporadic nests of opal mostly of the "common" type and of no commercial value, although some precious opal was once mined at Springsure. This appears to have been an isolated pocket. There seem to be no definite opal pipes, and nothing to permit one to recommend the district to opal hunters. "Hyalite" (water opal) is very common in the vesicles of the more coarsely vesicular basalts. Common opal occurs in the basalts, trachytes, and tuffs of Springsure and elsewhere. It is indeed widespread over the entire volcanic area, as are also agate, chalcedony, and rock crystal.

The volcanic rocks of the area can be divided into basalts, trachytes, rhyolites, and andesites, of which the basalts are by far the most plentiful.

The basalts cover most of the Dividing Range over 2,000 ft. in altitude. The areas covered by basalt are shown on the map, so nothing need be said about their distribution and extent. On the sandstone tableland country at the head of the Maranoa and Warrego Rivers the basalts constitute plugs, domes, and superficial cappings resting on sandstone at an elevation of from 1,700 to 2,000 ft. on and near the divide, and progressively lower as the divide is receded from.

North of the Dividing Range, as on Meteor Creek, Peawaddy Creek, and Consuelo Creek, the basalts attain a thickness of 1,000 ft. and over in places, flow having succeeded flow and having filled up earlier valleys. The basalts have poured down over low country about Meteor Station, Consuelo Station, and Rolleston not more than 600 to 800 ft. in altitude.

The opinion has been expressed by earlier geologists (Jack and Maitland) that there have been two eras of basalt extravasation, an earlier one before the tablelands were dissected and a later one after dissection had formed present valleys. This view is based on the very different levels of the basalt floor in the Springsure-Rolleston area as compared with the Mount Moffatt-Carnarvon area, and a comprehensive examination of the question leads one to the conclusion that the old view was the result of insufficient knowledge of the area as a whole.

Basalts.—The basalts vary widely in appearance, yet the different classes of basalt are found together in many parts, so that these classes of basalt cannot be said to have geographical limits. The differences are differences in the nature and composition of successive flows. Thus we have highly vesicular basalts interstratified with compact basalts, coarse with fine,

grey-coloured basalts with black basalts, olivine basalts with basalts free from olivine. The coarse grey basalts met with commonly on Meteor Creek, Vandyke, Cona, &c., are probably instrusive sills forced in between basalt flows in the later stages of the volcanic period.

The last basalt erupted was a black scoriaceous lava which is equally prevalent as the topmost flow in all regions from the Carnarvon-Marlong tablelands to the Springsure mountains, from the highest points of the range to the low-lying country down the lower reaches of Meteor and Consuelo valleys. This was, like the recent Savaii and Hawaian lavas, of a very mobile nature and flowed over a vast area. It is often coarsely vesicular and frequently has beautiful aggregates of hyalite in the larger vesicles.

Andesitic Basalts.—Forming the base of all the volcanic sequence at Springsure, Minerva, Rainworth, and in fact the entire north-south volcanic area comprised between Cardbeign and Minerva, we have a shingly greyish-black andesitic basalt of very fine-grained close texture. The sheets of this, viewed from afar, have a fairly constant dip to the south. There are two possible explanations of this—(1) That these lavas originated from craters between Springsure and Minerva and flowed south into a wide valley, a short-cut ancestor of the Nogoa which ran due east from Vandyke Creek, near the junction with Cona Creek, to Meteor Downs; the flows in that case can be regarded as Early Tertiary and the slope to the south is natural. (2) That these lavas are Permo-Carboniferous—Lower Bowen.

Dr. Richards and other investigators have regarded all the lavas of Springsure district as Tertiary, and it is, in the absence of strong evidence to the contrary, the most reasonable view to adopt.

Dr. H. C. Richards has already given a good account of the volcanic rocks of the Springsure district. (Vol. xxx., No. 14, Proc. Roy. Soc. of Q.)

The examination made by Mr. Shepherd, geological assistant, and the writer elicited nothing new about the volcanic rocks. The volcanic series at Springsure may be briefly stated to consist of an older formation of agglomerates, andesitic basalts and basalts, a middle series of trachyte breccias, and tuffs followed by flows of trachyte and rhyolite, and finally an upper series of vesicular basalts well developed on Mount Boorambool.

For details the reader is referred to Dr. Richards's paper. West of Minerva the trachytes and trachyte breccias do not invariably rest on an older volcanic foundation, but sometimes direct on sandstones of the Lower Bowen.

The Trachytes.—The Springsure trachytes have already been referred to, and a fuller description can be got from Dr. Richards's report.

In the Hoganthulla Range at Gee Gee Gap there is a considerable development of trachyte, which in this region forms the earliest of the volcanic rocks. It is a coarse porphyritic trachyte, or "bostonite," not unlike that of Gib Rock, near Mittagong, N.S.W., and Mount Beerburrum of the Glass House Mountains, Queensland. This rock forms the main component of the back of Hoganthulla Range between Gee Gee Gap and the Dividing Range. It rises from a sandstone basement at a height of 2,550 ft. in Gee Gee Gap to 3,080 ft. on a peak lying to the north of the pad in Gee Gee Gap. There were still higher trachyte mountains to the north, and the Dividing Range in this area seemed on the evidence of sculpture to be mainly trachyte. In some of the hills south of Gee Gee Gap, the sandstone reached up to 2,850 ft., lying nearly horizontal. The mountain ascended was no doubt a plug, hence its coarse texture.

More trachyte areas were met with on the country at the head of Sunday Creek and the upper branches of Deloogerah Creek.

No other trachytes were seen *in situ* in the Carnarvon Ranges, but loose pebbles and boulders were picked up in Buckland, Vandyke, and Meteor Creeks, proving that there are trachytes up these creeks covered mostly by basalt, but exposed in some of the rough tributary gorges.

Glenhaughton Trachyte.—About eight miles east of Glenhaughton head station, between it and Broadmere on the Taroom road, the road crosses a range attaining an altitude of 1,500 ft., Glenhaughton being about 900 ft. above sea-level. The topmost 300 ft. of this range is capped with trachyte. A bed of trachyte tuff lies between the Bundamba sandstone and the trachyte.

On this trachyte we get a fine red clayey soil growing a dense brigalow vine scrub, containing a peculiar intermixture of inland and coastal scrub trees and bushes. The sandstone basement under the volcanics was an uneven eroded surface prior to the extrusion of the lavas. On the sandstone country around the trachyte we get the usual spotted-gum forest with some gumtop ironbark, bloodwood, and a profusion of wattles with *Acacia Bancroftii* playing an important part.

It is interesting to note that, in recent surveys in connection with the Dawson irrigation scheme, Mr. E. L. Peart, surveyor, has collected trachyte porphyries on the Dawson River near the junction of Delusion Creek, and also between that point and Camboon woolshed.

Rhyolites.—Rocks of rhyolitic composition are found principally in conjunction with trachytes in the Springsure district. There are also some rhyolites associated with basalts, both of Lower Bowen age as far as can be gauged, south of the Nogoa River about portion 2, parish Yarrai. These rhyolites are vesicular, very altered, and contain zeolites of a flesh colour

(prehnite) very like some of the Permo-Carboniferous rhyolites in the Maitland and South Coast districts in New South Wales.

Andesites.—Andesitic basalts have already been dealt with. In addition a few andesite dykes have been noticed. One such formed a prominent feature on Buckland Creek about eight miles above Nardoo Station.

Dolerites and Diabases.—Diabases and altered doleritic basalts occur in profusion associated with green chloritic tuffs in the valley of the Nogoa at Emerald. It is considered that these are of Carboniferous age.

Tuffs.—In addition to the trachyte tuffs already mentioned, Tertiary basalt tuffs are widespread though mostly covered with basalt. Exposures occur, however, on Channing Creek (Carnarvon Station), Saddle Creek (branch of Buckland), Buckland Creek, and Deloogerah Creek at an elevation of 2,500 to 2,600 ft. above sea-level; on Peawaddy Creek, Meteor Creek, and Orion Creek and other creeks to the north of the Dividing Range at elevations of from 700 to 1,000 ft. above sea-level.

IV.—MINERAL RESOURCES OF THE CARNARVON RANGES.

Metallic Minerals.

No indications of ores of metallic minerals have been noticed, nor are the geological formations in this area favourable for the occurrence of metals: except perhaps in that small area of metamorphic rock which lies about six miles west of Rewan, where careful prospecting for metals and gems is warranted. The writer has seen copper ore reputed to have been picked up in the Snake Range, Telemon, south of Bogantungan, and it is also stated that a large low-grade metalliferous lode carrying copper, silver, and gold exists near Mount Beaufort, south of Pine Hill. However, both of these localities are outside the area of special investigation, and the ore deposits are in rocks as old as the Star Series, or older. The Snake Range deposit is probably in rocks of the Anakie Series.

A prospector, Mr. Penny, has informed the writer that many years ago he found gold east of Planet Downs in the Expedition Range, where there may be a small pinnacle of ancient rock.

Non-Metallic Minerals.

Asbestos has been submitted to the Geological Survey from a locality about five miles north of Eddystone Vale Station. The area of metamorphic rock must be very small, probably a buried pinnacle.

Opal.

In Part B opal has been mentioned as occurring under basalt at Amby, Mount Hutton, and elsewhere, but not in

sufficiently well-defined bodies to offer much encouragement to prospectors. Opal is likely to occur in a similar manner in many places north of the Dividing Range, but not in pipes of economic importance.

Wood opal, however, occurs in large blows in places on Meteor and Albinia Downs. Precious opal has been mined at Springsure, but it occurs in sporadic pockets, and no indications were seen of any opal pipe to encourage further prospecting. It is, however, possible to get very valuable pockets of precious opal in any of the volcanic rocks of the Carnarvon Ranges and Springsure district, and men whose occupation takes them through the district would be well advised to be always on the lookout for opal.

Agate.

Very beautiful agates occur scattered about on the surface in many places on the volcanic areas; however, they are of no commercial value.

Sulphur.

This mineral occurs as a precipitate in mud, deposited by mound springs on Crystal Brook Station. It is not a deposit of commercial value, but appears to be due to chemical interaction between sulphuretted hydrogen and sulphur dioxide gases carried up in these spring waters, or simply from bacterial action on sulphuretted hydrogen carried up in the water. The source cannot be stated.

Coal.

By far the most important mineral definitely located in the area is coal.

The coal occurrences south of the Dividing Range have already been mentioned in Part B. South of the Dividing Range coal has been observed in the following localities:—

(1) *Buckland Creek.*—A large coal-seam of very inferior quality showed in the banks of the creek six or seven miles above Nardoo Station. It belongs to the upper measures.

(2) *Vandyke Creek.*—On Vandyke Creek two different seams each about 7 ft. thick were mentioned to the writer, who, however, saw neither. As it was quite impracticable to follow the bed of the creek, it is quite possible that these seams exist. Although the bed of the creek was examined at frequent intervals and no coal fragments seen except in one belt to be mentioned later, the coal may have been missed, as coal does not carry far. A prospector named Fegan is supposed to have discovered one of the above reputed seams, and Mr. Sypher informed the writer that he has several times seen a big seam in the Mount Sunday region of Vandyke Creek, which in fact is an area so largely basalt-capped that only a short exposure can be expected. This seam is certainly one of the Upper Bowen seams, whereas Fegan's may belong to the Middle Bowen belt.

In the writer's traverse up Vandyke Creek he found fragments of coal of very good quality on the Big Vandyke about five miles above the Rocks (junction of Big Vandyke and Little Vandyke). The seam itself was not seen in outcrop. Still it can be safely said that the horizon of this coal is approximately the same as of Sypher's seam on Little Vandyke.

(3) *Cona Creek.*—No coal was actually met with, but a Mr. Smith, of Springsure, stated to the writer that years ago when fencing on that creek he came across two big coal-seams. These would be Upper Bowen coal measure strata, but no seams were met with. The creek as far as examined is very muddy except where a few sandstone floors showed.

(4) *Peawaddy Creek.*—Peawaddy Creek showed coal measure formations of the Middle Bowen type, but no actual coal was exposed.

(5) *Consuelo Creek.*—Seven miles below Rewan police station and about seventeen miles above Consuelo Station, the writer examined three coal-seams which occur in close proximity. Two of these seams are probably identical with the seams sampled by the Parliamentary Royal Commission for Railways about twelve months previously. The thickness and analysis of these seams is given as follows in the Geological Survey register:—

(1) 8-ft. seam—	Per cent.	(2) 4-ft. exposure—	Per cent.
Moisture	9·4	Moisture	11·9
Volatile hydrocarbons	28·6	Volatile hydrocarbons	30·5
Fixed carbon	58·4	Fixed carbon ..	54·9
Ash	3·8	Ash	2·7

The Commission's 8-ft. seam is probably the same as the writer's top seam of the three seams examined. This seam dips to the east slightly south at 15 deg. Allowing for dip, there was over 8 ft. of coal in sight to the water's edge, and there seemed to be several feet below the water. The bottom of the seam was not in sight. There is probably over 10 ft. of coal in the seam. There are no bands in it.

The 4-ft. seam occurs on the other side of the creek about 100 yds. lower down and would be roughly 40 ft. lower. This seam examined showed 36 in. of clean coal overlying a white fireclay. Above the 36-in. coal-seam there was 6 in. brown coaly shale, then another 18 in. of coal, followed by blue shale 4 ft., then ironstone 6 in., then alternating bands of ironstone and sandstone. Fragments of Glossopteris and Neocalamites were seen in the brown shale. The upper seam has fireclay below and is overlain by clay shale and ironstone.

The third seam is a dirty seam consisting of alternating bands of coal and shale for a thickness of 15 ft. It occurs about six chains further down Consuelo Creek, and is not a workable proposition.

The latter seam is much lower in the series. The first two seams were so similar in quality that only one sample was taken, containing a representative mixture of 8 ft. of the upper and 36 in. of the lower. Analysis of this sample gave—

Moisture	10·8 %
Volatile hydrocarbons	29·8 %
Fixed carbon	52·3 %
Ash	7·1 %
Calories per kilo	5,510
British thermal units	9,918
Lb. of water evaporated at and over 212 deg. F. by 1 lb. of coal	10·3

Coking test: the sample did not coke.

The ash is greater in the writer's sample largely on account of the muddiness of the surface after recent floods. All these analyses show the coal to be of excellent quality, and when railway communication is gained by these parts the locality will be of great value. The coal appears, however, to be somewhat friable, so that there would be a fair amount of waste in mining. The dip is rather steep at the outcrop, but flattens to about 5 deg. in a mile or so eastward.

There are said to be other coal seams or outcrops on Consuelo Creek, which is quite likely since the creek runs for twenty miles, practically from Mount Carnarvon to Consuelo Station along the line of strike of these coal measures.

The Consuelo seams belong to the Middle Bowen Series.

It is stated at Springsure that coal has been obtained in well-sinking at Cairdbeign Station and in several other places in the Springsure district. This is probably quite true. The Cairdbeign coal would be identical with the Consuelo coal in geological age.

(6) *Carnarvon Creek.*—Two important coal-seams were located on Wells's block, portion 2, parish Aubrey, on Carnarvon Creek, in a gully entering the main creek from the east. One of these seams was known to the station people, having once been on fire for several years. This was the upper seam. About 50 yds. higher up the same gully there is a body of kerosene shale to be mentioned later, and about the same distance down the gully is the lower coal-seam. The upper seam (formerly "burning seam") showed 3 ft. 6 in. of clean coal above the mud, but allowing for the width of outcrop and dip the coal-seam has a thickness of over 8 ft. It cannot be said, in view of the mud in the gully, if the lower 4 ft. 6 in. of coal is as clean and good as the top coal. The lower seam has an exposure over 4 ft. thick, and the bottom of the seam is not in sight. The two seams are about 60 ft. apart in vertical distance. Yellow felspathic sandstone and ironstone overlie each seam, an ironstone bed 12 in. thick being a couple of feet above each coal-bed. The dip is constant south-east at 7 deg. between the seams.

The two coals were of the same character and quality. Only the top seam was sampled, the sample yielding:—

Moisture	10·7 %
Volatile hydrocarbons	31·1 %
Fixed carbon	53·9 %
Ash	4·3 %
Calories, per kilo	6,202
British thermal units	11,164
Lb. of water evaporated at and from 212 deg. by 1 lb. of coal	11·6

The coal was non-coking.

The ground rises more steeply between the upper seam and the oil shale above. The vertical distance between these two beds would be approximately 70 ft.

There would be no engineering difficulties whatever in railway construction from Rolleston up the Consuelo past the Consuelo coal-seam to the Carnarvon seams, though the distance to Springsure *viâ* Rolleston would be 100 miles approximately.

There would be no difficulty in making the road fit for motor traffic and for motor lorries in the dry season, as far as the Carnarvon coals, the country being mostly very flat up the Consuelo and across Rewan. This question is raised in connection with the possibility of working the oil shale using the adjacent coal to distil it.

(7) *Moolayamber Creek and Brown River.*—A small fragment of coal was found in Bullaroo Creek, but its source is doubtful. Small fragments of coal have also been seen in the Brown River below Carnarvon Creek, but, although they probably were derived quite locally, the banks were so decked with flood-silts that no outcrop was located.

(8) *Bedourie.*—Records show that coal was once found near Bedourie, but the writer could neither get particulars nor find any trace.

(9) Coal occurs in wells and bores around Taroom, also on Rochedale Creek between Taroom and Juandah and also at Juandah. These are dealt with in a later section.

Kerosene Shale.

On Carnarvon Creek, about 50 yds. above the "burning" coal-seam and on the same gully, the writer located a bed of beautiful black conchoidal-fractured kerosene shale 3 ft. in thickness. This is about 70 ft. vertical above the upper coal. A 6-in. band of shale occurs under the oil shale, and below this another 6 in. of oil shale. About 50 yds. higher up the gully there is yet another 6-in. seam of oil shale.

The largest seam was sampled across the thickness, and the average sample, though weathered, affected by the sun, moisture,

and bush fires, yielded 54 gallons of kerosene per ton. This result is eminently satisfactory, being the best yield of any shales so far tested in the State.

The coal for distilling the shale is right on the ground. The environment should be tested by diamond drilling to determine the extent of the shale body. Probably others would be pierced which have no exposure on the surface.

A small east-west fault occurs immediately north of the gully in which the coal and oil shale are exposed, and no data could be got for estimating the amount and direction of throw.

Kerosene shale has also been found on Warrinilla Station in Carnarvon Creek. This is on the same belt of country, but the outcrop could not be located.

Petroleum (Liquid).

The chances of petroleum should be very bright in the Upper Bowen belt, for the following reasons:—

(1) The strata are deltaic deposits, interbedded sandstones, shales, limestones, and carbonaceous beds of the type and succession characteristic of the best of the world's oilfields.

(2) An escape of natural inflammable gas has been noted at Mount Moffatt about ten miles south-west of the Carnarvon oil shale locality.

(3) Oil shales occur in the series.

(4) The series is gently folded, and the task of locating anticlines and monoclines is easy as compared with the Maranoa owing to the deeper erosion.

(5) Salt springs are mentioned as occurring at the head of the Moolayamber, Carnarvon Creek, Consuelo Creek, and on Tommy's Creek (a branch of Clematis Creek), all in the same belt, and all this belt of country is shown by the vegetation to be rather saline.

(6) The sandstones of the series and those below are of a very porous nature, and do not yield artesian water like those of Roma and the region south of the Dividing Range.

(7) In the region of the Dividing Range, oil pockets like those of the Mexican fields, formed by the distillation of oil shale in the vicinity of volcanic necks, might be exposed.

Tripolite.

A deposit of tripolite which the writer has not visited occurs on Planet Downs.

Alum.

An alum deposit occurs on Vandyke Creek, which has been described by Dr. Richards in the Proc. Roy. Soc. of Q., vol. xxx., No. 15.

V.—FOLDING AND FAULTING.

Folding.

The entire series of formations of the Carnarvon Ranges is tilted towards the south, but, in addition to a general uplift with its maximum activity in the Anakie region giving us this southerly dip, there are superimposed folds with north-south axes which cause east-west tilts. These combining with the southerly tilt give dips usually south-east, south, and south-west, and between those directions.

One anticline has its axis practically along Vandyke Creek. Its intensity rapidly declines in a southerly direction, so that it almost dies out before one gets to the Rocks at the junction of the tributaries east of Mount Sunday.

Another far more important anticline has its centre on a line passing through Anakie, Springsure, Meteor Creek at the Gorge (Sandy Creek), Mount Sericold, &c. This anticline is very intense in the Mount Sericold region, having apparently been here accentuated by volcanic eruptions in the Tertiary. It becomes very gentle again south of Rewan, though indications of the same movement are seen at Jack's Mountain, near Boxvale, and to a slight extent further south. The direction produced cuts the Charleville line between Roma and Wallumbilla.

The Expedition Range occupies the position of a great, wide syncline which extends in a sweeping curve to the Taroom district.

Minor folds are present and innumerable. The location of such, however, falls within the scope of detail geological survey which must follow work of a general nature like the present.

Faulting.

Minor faults have been noticed in many places, but cannot be discussed in a general report like this. It might be said that they occur mostly in the neighbourhood of volcanic masses, and are of Tertiary-basaltic age.

There is, however, one great fault or system of almost colinear and genetically connected faults which has affected the entire region from Amby on the Charleville line to Springsure. In the Consuelo district, it cuts through about a mile east of Black Alley Peak, and through Mount Sericold north of this it probably passes Mount Hope, Mount Kelman, Mount Rainworth, and the Springsure mountains under a huge basalt sheet. It is probably along this same fissure the Clermont basalts have found

escape, and indications of colinear volcanic outpourings can be seen on the geological map as far north as the mouth of the Burdekin River.

The downthrow along this fault all the way from Amby to Springsure has been the western side. The actual shifting of outcrops due to this fault amounts to over ten miles in places where the dip is slight. The vertical throw cannot be less than 500 ft. and probably exceeds 1,000 ft. Sufficient data have not been accumulated to give the throw within definite limits, but the geological effects are so pronounced that it can be said to be a fault of great magnitude. It is probable that it was formed just prior to the basic eruptions which found their vents along its course.

This fault may prove of great importance in later oil surveys.

VI.—PALÆONTOLOGICAL AND STRATIGRAPHICAL NOTES.

(1) Plants.

Thinnfeldia odontopteroides was collected on the Bullaroo Creek, a branch of the Moolayamber near the head of Spring Creek, a branch of the Brown River, and about twelve miles above Nardoo on Buckland Creek. In each of these places it was associated with Sphenopteris, Phyllotheca sp., Neocalamites?, Schizoneura, Annularia?, and other genera, doubtful since stems alone were seen.

Glossopteris sp. was also seen in the Middle Bowen coal measures in shales too friable to be carried. It seemed to be associated with Gangamopteris sp., in shales on Consuelo Creek.

Fossil wood, as already mentioned, has been collected—

(*a*) In the Middle Bowen;

(*b*) In the Upper Bowen on Vandyke and Spring Creeks (branch of Vandyke), Wealwandangie, Black Alley Mountain, Carnarvon Creek near coal and kerosene shale outcrop, Rewan near the Crater, Moolayamber Creek, Warrinilla, Clematis Creek, Buckland Creek, &c.;

(*c*) In the Ipswich on Buckland Creek, Moolayamber Creek, Spring Creek (Brown River branch), Bedourie, &c.;

(*d*) In the Bundamba over wide areas mentioned in Part B and also on Glenhaughton, Wallangara Creek, and the tributaries of the Robinson;

(*e*) In the Walloon between Broadmere, Taroom, and Juandah;

(*f*) In the Tertiary under basalts.

Lepidodendron veltheimianum was collected in the Star Series at Bogantungan.

Glossopteris Browniana was collected as well-preserved impressions on Vandyke Creek, east and south-east of Mount Sunday. Here it is associated with Sphenopteris (or Ovopteris species not distinct). The same association was noticed on Freitag Creek in a south-east direction from Wealwandangie head station, but the rock was too frail for collection and transport. On Buckland Creek between six and eight miles above Nardoo, Glossopteris remains were also seen in friable shales and mudstones. These localities all lie in the zone of the Upper Bowen coal measures.

Near Carnarvon Creek, on Wells's lease about a mile north of the coal and kerosene shale locality, well-preserved impressions with *Glossopteris Browniana* were associated with *Gangamopteris angustifolia* in the Upper Bowen coal measure shales. The fossiliferous shale was baked or indurated almost to chert, hence the fossils were well preserved.

This association has also been noticed by Mr. B. Dunstan in his Upper Freshwater Series in the Dawson-Mackenzie area, from which it seems that in Queensland, Gangamopteris species (*angustifolia* and *Clarkii*) occur associated with *Glossopteris Browniana* even in the upper measures of the Middle Bowen and the lower measures of the Upper Bowen.

In all these Upper Bowen localities fossilised stems of Phyllotheca sp., Neocalamites, and allied genera were very abundant, but they get even more abundant in the Ipswich Series, in which exactly similar fluted and annulated stems are associated with Thinnfeldia.

(2) Marine Fossils.

A complete list of fossils collected in the area is given in Appendix II.

(3) Stratigraphical Notes.

Dr. Jack remarks, in "Geology of Queensland":—"From its organic remains, lithological character, and position, I have no hesitation in regarding the Upper Bowen formation as the equivalent of the 'Tomago,' East Maitland (productive coal measures) 5,700 ft. thick; Dempsey Series (barren freshwater beds) 2,000 ft. thick; and Newcastle Series (productive coal measures) about 1,150 ft. thick, of New South Wales."

In the district here under review it can also be said that the Upper Bowen is absolutely the equivalent of the Tomago, Dempsey, and Newcastle Series of New South Wales.

The crinoidal shales of N.S.W. are the equivalent of the Upper Marine horizon in the Carnarvon area, and would, in Dr. Jack's grouping of the Bowens belong to the top of the Middle Bowen Marine Series. In our district, however, the

Middle Bowens are more freshwater than marine, hence it has been considered advisable to take the Lower Marine (which is only a comparatively thin series) with the Lower Bowen, and the Upper Marine (also a thin series) with the Upper Bowen. It is purely as a matter of convenience, and it would be equally reasonable to consider these two marine horizons as respectively the base and top of the Middle Bowen. This view would bring the series more into line with the N.S.W. sequence.

In the Bowen district, Mr. Jack's type area, the Lower Bowen Series consists mainly of volcanic rocks. In the Pioneer district volcanic rocks are interbedded with conglomerates, grits, and sandstones in the Lower Bowen Series. In the district under review in this report, the volcanic rocks are represented, but only sparingly—unless the lower volcanics at Springsure should ultimately prove to be of Bowen age. The series consists of conglomerates, grits, sandstones, varve shales, olive shales with volcanics in places, and correspond exceedingly well to the beds which in the Hunter River district of N.S.W. overlie the Pre-Kuttung (David and others, Jour. Roy. Soc. N.S.W., vol. liii., 1919). The Kuttung Series is represented by the lower glacial conglomerates and tillite of the Nogoa; the rhyolite horizon of the Nogoa would be the equivalent of the Paterson rhyolite of N.S.W.; and the upper conglomerates and tillites are probably the equivalents of the glacial beds above the Paterson rhyolite and of the Brandon sandstones and conglomerate.

Dr. Jack's Middle Bowen in the type area is largely a marine formation, though not wholly so, for two coal-seams occur in the middle of the series. Glacial conglomerates are described as occurring in the basal measures, and calcareous rocks with lower marine fossils also occur. The marine formations lying on the top of the Lower Bowen glacial conglomerates, sandstones, tillite series in the Springsure-Nogoa district, and which yielded the Dilly fossils, are the equivalent of the base of Dr. Jack's Middle Bowen. It is also the equivalent of the *Eurydesma cordatum* horizon in the Hunter River district; and if some of the Springsure basalt should prove Permo-Carboniferous it would be the equivalent of the natrolite basalt and tuff in the Hunter district.

Above this marine series we have a great thickness of sandstone commencing with a pebbly conglomerate. This series contains many red sandstone and ironstone beds. It is equivalent to the Ravensfield sandstone of N.S.W. On top of it we get the "Lower Coal Measures" of the Bowens. They lie in the middle of the Middle Bowen Series. They seem to be the equivalent of Mr. Dunstan's Lower Coal Measure of his Lower Bowen, and are also equivalent to Jack's Garrick and Kennedy seams of the Bowen Coalfield. They correspond to the Greta of N.S.W.

The sandstones overlying these contain many ferruginous horizons and finish with the Tumbledown formation. In the

Carnarvon areas they seem essentially freshwater formations, as indeed they seem to be in most parts of Queensland until the Upper Marine is reached, which in Dr. Jack's classification would be mostly included in the Middle Bowen, but which is here for convenience taken as the basal bed of the Upper Bowen. This sandstone series is the equivalent of Maitland's Middle Bowen freshwater sandstones and of the Upper Marine in N.S.W.

The Upper Marine in the Carnarvon area is in this report taken as the base of the Upper Bowen. It is equivalent to the crinoidal shales under the Tomago in N.S.W., while the coal measures of the district under review are identical with Mr. Dunstan's Upper Freshwater (of Mr. Dunstan's Lower Bowen), Mr. Jack's Upper Bowen, and the N.S.W. Tomago beds. In the Upper Bowen beds described in this report there seems to be no coals above this horizon, although there may be beds which have been missed, like the one which yielded fragments of coal in Bullaroo Creek, and the one reputed to exist near Bedourie. If coal beds exist in these localities, they would be equivalent to the Newcastle.

The Tolmies coal series is apparently represented in the Carnarvon area by yellow sandstones which form passage beds between the Upper Bowen and Ipswich. These contain abundant Phyllotheca and pass upwards into Thinnfeldia beds (Ipswich). They are probably equivalent to the Narrabeen shales of N.S.W.

For reasons already given in Part B the Bundamba sandstones are in this report regarded as practically the equivalent of the Hawkesbury sandstone of N.S.W.

It is a strange fact, difficult of explanation, that wide areas of the earth's surface were covered with sediments of much the same kind in the same period.

The Walloon formations are remarkably similar over a very wide area of New South Wales and Queensland. The uppermost beds of the Walloon, formerly Blythesdale Braystone, are a similar formation from central New South Wales to Cape York. We now call it Upper Jurassic. We know the age from the passage of this formation into the Lower Cretaceous Marine in places like Croydon. This Upper Jurassic sandstone lies conformably in the Walloon sequence in the Roma and Maranoa districts, but rests unconformably on old palæozoic rocks north of the Central Railway. It is less difficult to understand why the Cretaceous Marine should have the same characters throughout Eastern Australia. The wide distribution of the Cretaceo-Tertiary Desert Sandstones through Australia and the similarity of the beds of that age is another remarkable feature, and again the uniformity of the Triassic (?) Hawkesbury-Bundamba sandstone is equally remarkable.

Prof. T. G. Taylor's paper "Climatic Cycles and Evolution"

helps to cast some light on the reason of such widespread similarity of rocks of the same age. (The Geographical Review, vol. viii., No. 6, Dec. 1919.)

In Palæozoic times no doubt the same laws held. It is therefore fair and reasonable to accept that the Bowen formations commence with volcanic rocks, glacial conglomerates, and varve shales. The term "Lower Bowen" should not have been corrupted into synonymous with "Lower Permo-Carboniferous," but should have been kept for the series of rock types determined for the Bowen district below the Middle Bowen (Marine).

Dr. Jack's classification of the Bowen beds is followed in most respects in this report. The Lower Bowen of this report and of Dr. Jack is equivalent to Upper and Middle Carboniferous; the Middle Bowen to the Lower Permo-Carboniferous, including Lower Marine, Greta, and Upper Marine (in part) of New South Wales; and the Upper Bowen of this report is equivalent (leaving out the small basal marine horizon) to the Tomago, Dempsey, and Newcastle coal measures of the Upper Permo-Carboniferous.

The Tolmie beds and Bullaroo Creek sandstone, Bedourie sandstone under the Thinnfeldia beds, are equivalent to true Permian, and are the Narrabeen of N.S.W. passing into Triassic Thinnfeldia beds.

The Star Series is Lower Carboniferous.

The close similarity between the Queensland sequence (in the Carnarvons) and that of N.S.W. is seen in the following sections:—

Queensland.		New South Wales.	
Carnarvon Range Area.		Hunter River District.	
Beds.	Thickness.	Beds.	Thickness.
	Ft.		Ft.
1. Ipswich—		Narrabeen	..
(a) Shales, tuffy shales, limestones	2,000		
(b) Sandstones	2,000		
2. Upper Bowen—			
(a) Shingly sandstones (Clematis series)	2,200	Dempsey beds	2,000
(b) Coal measures	1,200	Tomago beds	1,000
(c) Marine limestones, &c. ..	450	Crinoidal shales	2,600
3. Middle Bowen—			
(a) Upper sandstone ..	2,000–3,000	Upper marine beds	3,400
(b) Coal measures ..	1,800	Greta beds	300
(c) Lower sandstone ..	6,000	Ravensfield sandstone	..
4. Lower Bowen marine Eurydesma beds, and glacial	7,000	Eurydesma beds, glacial beds, Lower Marine, and Brandon conglomerate	4,300

Cp. Jour. Proc. Roy. Soc. N.S.W., vol. liii., plate xxix.

The thickness of these two series is likely to be much overestimated owing to dips above the normal being much more

likely to be exposed than flat dips in country of a greatly undulating or plain-like nature.

According to Suess in "Das Antletz der Erde," the mountain chains of Eastern Australia are mostly fold-chains, and the folds are directed north and south. He points out, however, that in Victoria the mountains are oriented east and west, while the fold axes continue north and south. Suess was not aware that in Central Queensland the fold axes are mostly oriented on east-west lines. This is due to the fact, already pointed out by the writer elsewhere,* that the northern parts of this State are geologically continuous with the Northern Territory and Central Australia, and constitute part of the same massif which has been dry land since the end of the Cambrian period, except for a transgression in the late Permo-Carboniferous (Arnheim Land sandstones) and another in the late Cretaceous.

On this palæozoic massif, the mountain chains, composed of Silurian and Devonian and later sediments, have been moulded. Mountain-building movements ceased in North Queensland after the Devonian; later rocks are but little disturbed (*see* "Some Geological Features of Northern Australia"*).

However, we have ample evidence that in the eastern parts of Central and Southern Queensland sedimentation proceeded apace during the Carboniferous, Permo-Carboniferous, and Mesozoic periods, and folding continued even into Tertiary times.

The fold ranges of older palæozoic sediments in Central Queensland are moulded on the shore-lines of the Archæan massif of North Queensland and the Northern Territory, which in late palæozoic times in consequence had its land area considerably extended towards the east.

The writer has pointed out, in the paper mentioned, that, stage by stage as we recede from the Archæan continent, the period to which folding was continued becomes progressively later; hence we see in Central Queensland the spectacle of the Star and Bowen beds lying but little altered, and the Bowens only gently tilted in the western parts as in the Carnarvons and the Drummond Range, while in the coastal ranges the same rocks are highly altered, intensely folded, and often contorted. Isostatic movements mainly affected the western parts, while compressional forces acted severely on the eastern parts.

When the Star and Bowen beds of the Central West had been added to the area affected only by continental movements of wide uplift and depression, the Mesozoic transgressions affected the borders. Subsequent vertical uplifts of the expanded continental area account for the general southerly lift of the Bowen and Mesozoic beds referred to in past pages. These two

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* Proc. Roy. Soc. of Q., 1922.

account for the average west-north-west strike direction of the Permo-Carboniferous (in part) and the Mesozoic belts on the map.

The area described by Mr. Dunstan in his report on the Dawson and Mackenzie is probably the most difficult to study, because it lies on the hinge-line between the continental (isostatic) portion of the continent and the accumulated pile of oceanic sediments undergoing violent folding.

It is probable that the Northern Territory massif became connected with the Cobar massif and through it with the Kosciusko massif at the end of the Palæozoic era, leaving a wide bay over South-eastern Queensland and Northern N.S.W. which soon for some reason became lacustrine as evidenced by our dominant mesozoic deposits. Concerning these, Suess remarks, quoting the French translation, La Face de la Terre: "Audessus des formations marine carbonifèrés on observe dans tout le domaine de la Cordillère une lacune très étendue, et très remarquable dans la série des sédiments marins, lacune qui va jusqu'au Crétacé. À la place des dépôts marins se présente une série variée de couches à végétaux, au nombre desquelles se trouvent des grès regardés comme étant d'origine éolienne. La diversité des flores, qui se dégageait défa des recherches de Feistmantel a été mise en plein lumière par Tenison-Woods; elle est si grande, q'avec le progrès de ces études on arrivera probablement a distinguer dans le domaine de la Cordillère australienne la plupart des divisions reconnues dans la série indienne du Gondwana."

These Gondwana floras Suess summarises as—

(1) Devonian.—*Lepidodendron nothum* with Cordaites, Sigillaria, and Archæopteris.

(2) Culm.—*Lepidodendron veltheimianum* with *Calamites radiatus, Cyclostigma australis, Rhacopteris inequilaterale.*

(3) Carboniferous.—The flora of *Glossopteris Browniana* and glacial beds equivalent to the Talchir of India.

(4) Permian.—Glossopteris.

(5) The Clarence Beds.—Thinnfeldia and Tæniopteris flora (Triassic).

The Permian of Suess is in reality the Upper Bowen coal and Tolmies coal measures.

Now, while, as Suess remarks, we have in Eastern Australia an entire break in marine sedimentation from the Permian (for he is wrong in dating this break back to the Carboniferous) to the Cretaceous, in West Australia Marine Jurassic strata have been laid down.

"Les explorateurs partis," says Suess, "de la côte nordouest n'ont également rencontré que du granite et du grès, peutêtre aussi du basalte, par example sur les bords du fleuve Victoria.

C'est seulement a partir du Glenelg River entre 15 deg. et 16 deg. de lat. S. qu'on a signale des fossiles incontestablement jurassique; c'est avec indication de prevenance qu'ils sont arrives en Europe et que Neumayr les a décrits. Ils présentent la plus grande resemblances avec les espèces recoueillies par Gregory, et ses successeurs dans les partie méridionale de la côte Ouest. On n'a jamais rencontré jusqu'ici de gisements semblables dans le centre ou dans l'Est de l'Australie, et nous devont provisoirement considérer ces sediments jurassique, si intéressants qui rappelle tant les depôts jurassiques de l'Europe comme limité à la partie occidentale du plateau."

Thus we see that the Archæan massif of Central Australia completely splits our Australian mesozoic beds into an Eastern Australian freshwater series, and a West Australian marine series quite similar to European marine mesozoic strata.

In another place Suess remarks that folding from west to east is indicated in Queensland by the trend of the ranges parallel to the coast-line. This is in the writer's opinion a misconception. The folding in Eastern Australia has been from east to west up against the massif.

As shown elsewhere, land conditions have prevailed in North Queensland from the Carboniferous to the Cretaceous, though there were a Middle Bowen transgression (Mulligan Coal Measures), and a Jurassic (Upper Walloon) transgression, both freshwater, prior to the Cretaceous marine transgression.

The mesozoic continental mass was affected only by these transgressions, but not continuously sedimented like the Carnarvons, and extended south to the vicinity of Tambo. West of the great Drummond mass of Carboniferous rocks it is probable that the Lower Walloon, Bundamba, and Ipswich beds were never deposited. Hart's deep bore at Springleigh shows a remarkable section which indicates to the writer that it passes from Cretaceous rocks at 3,650 ft. into Upper Jurassic, and at 4,600 ft. passes out of Jurassic rocks into the Upper and Middle Bowen Coal Measures. It is in these the oil and paraffin indications were met with. The sequence of strata in the Hughenden district, Mount Mulligan, and other places is similar.

It appears, therefore, that the Lower Walloon, Ipswich, and Bundamba formations were laid down in a depression which only affects South Queensland and which probably only extended but slightly beyond Charleville. These beds disappear in the region north-west of the Carnarvons under a mantle of desert sandstone, and hitherto no one has determined what trend they take west of Boggarella. They probably swing to the south in that region.

The Eromango (Lat. 20° 40′, long. 143° 16′) bore No. 1 and also No. 2 present sections very much unlike the usual section of the Marine Cretaceous. In No. 2 bore galena was noted between 500 and 600 ft., and again at 3,595 ft., and in

both bores the section is more likely to represent Bowen or Cambrian beds than Cretaceous below 500 ft. Galena is known in the Bowen formations and in the Cambrian limestones of the Barkly Tablelands, but is not known in our Marine Cretaceous except in water-borne fragments of rock. The Middleton bore and the Bedourie bore (Lat. 24° 22′, long. 39° 29′) are also below 1,000 ft. in strata unlike the usual Cretaceous-Jurassic section. The numerous pebbly beds shown in the strata pierced are very characteristic of the Bowen formations.

While it is quite possible that the nature of the sedimentation in the western parts of the artesian basin differed from that in the eastern parts during the Cretaceous and Jurassic, it is also quite possible that the porous Bowen strata lying unconformably against the old Cambrian on the north-east line of the Mulligan River, Sandringham, and Warenda may be artesian in this region, just as they are in the Northern Territory at Borroloola and Port Keats, where they similarly abut against the Cambrian limestones of the Barkly Tablelands and the Daly River. These limestones are rich in sub-artesian water.

At Coorabulka No. 5 (Lat. 24° 6′, long. 140° 22′) we get cretaceous rocks to 1,000 ft., and below that coal measure formation which may be either Walloon or Bowen, but which on the evidence of black and green sands or sandstone is more likely to be Upper Bowen.

The Jericho bore (Lat. 23° 36′ 30″, long. 146° 7′ 30″) commences in Cretaceo-Tertiary Desert Sandstone and soon passes at 1,700 ft. into dry beds which are most likely of Bowen age, after passing through some Cretaceous Marine.

The Thornleigh bore (Lat. 24° 19′ 35″, long. 144° 56′ 20″) passes into Jurassic rocks at 3,100 ft. The Blackall woolscour bore (Lat. 24° 23′ 40″, long. 145° 29′ 30″) passes into the same series at 1,300 ft. The Malvern Hills bore (Lat. 24° 31′, long. 144° 30″) passes into the Jurassic at 1,300 ft.

The bores between Tambo and Alpha at Eastbourne, Rocky, Doyle's, Bailey's, &c., are interesting in showing—(*a*) variable thicknesses of Cretaceo-Tertiary rock which show that the Cretaceous Marine was well named "Rolling Downs" on account of its rolling surface on which the Cretaceo-Tertiary lies unconformably; (*b*) the presence of kerosene shale in the Desert Sandstone here—a brown shale like that of the Boyne Valley and Central Queensland coast. There is just a possibility, but it is not probable, that the kerosene shale in these localities belongs to the Upper Bowen, in which case present notions as to the configuration of the artesian basin will need some change.

Our ignorance of the nature of the artesian basin and of the origin of artesian water is very great. This ignorance may be the cause of much waste of water on the one hand by not closing down bores, as suggested by some, and destruction of bores without doing any good at all, on the other hand, as

held by others. If we knew definitely what horizons the water can come from we would be in a better position to build up a satisfactory theory of origin. This knowledge can only be gained by diamond drilling. All Government water bores should be put down mostly by diamond drilling to get this valuable information, which cores alone can give us. The expense is greater, but the knowledge is worth it.

There is this further aspect, that through our ignorance of our artesian basin we may be doing enormous harm to potential oilfields, letting in water emulsifying the oils. Hence, still more need for more light.

The Artesian Basin in Southern Queensland overlies our Lower Walloon and Upper Bowen potential oil horizons; in North Queensland it overlies our Jurassic and Upper Bowen potential oil horizons. Water and oil problems are inextricably interwoven. Hence these remarks.

APPENDIX I.

Plant Fossils collected by H. I. Jensen.

Species.	Locality.	Horizon.	Matrix.
1. *Sphenopteris lobifolia*. Morris *Cladophlebis Roylei* Arber Glossopteris sp. 2. *Glossopteris indica* Schimper Phyllotheca sp. (stem) 3. *Sphenopteris polymorpha* Feist. *S. lobifolia* Morris .. 4. Glossopteris sp. .. 5. *Sphenopteris lobifolia* Morris *Glossopteris Browniana* Brong. 6. Do. .. .. 7. *Gangamopteris cyclopteroides* Feist. *Glossopteris indica* Schimper *G. Browniana* Brong... *G. ampla* Dana .. 8. *Gangamopteris angustifolia* McCoy . *Glossopteris ? Jonesi* Walkom (fragment) on reverse Phyllotheca sp. (stem) *Glossopteris indica* Schimper *G. Browniana* ..	About 10-15 miles S. of Bowen Coalfield	My Middle Bowen overlying the lowest Marine Pelican Creek Limestone	Green to brown shaly mudstone
	Right bank Dawson River (Long. 150°, lat. 125°)	My Upper Bowen Coal Measures	Reddish-brown shale
9. ? Nœggerathiopsis (fragment)	Dawson River, left bank		
10. *Sphenopteris lobifolia* Morris			
11. Glossopteri sp. ..	Vandyke Creek..	do.	Grey calcareous gritty mudstone
12. *Glossopteris ampla* Dana			
13. *Glossopteris Browniana* Brong.			
14. *Gangamopteris angustifolia* McCoy with Glossopteris overlying upper portion)	Carnarvon Creek	do.	White siliclous aluminous shale
15. *Gangamopteris angustifolia* McCoy			
16. Do.			
17. Do.			
18. Do.			
19. Do.			

Marine Fossils collected by Dr. Jensen.

No.	Locality.	Species.
1, 2, 3, 4, 5, 9	Limestone E. of Black Alley Peak	Trachypora sp.
4, 6, 7 ..	Black Alley Peak, Consuelo Creek	Crinoids
8 ..	2 miles E. of Black Alley Peak	*Strophalosia Clarkii*
10 ..	Limestones with erratics overlying coal, Pelican Creek	*Chænomya ? Etheridgei*
11 ..	Limestone overlying Lower Bowen Coal ..	*Productus brachythærus* Productus sp. *Strophalosia Clarkii*
12 ..	Buckland Creek	*Martiniopsis subradiata*
13 ..	Do.	No specimen, but loose paper upon which is written *Spirifera bisulcata*
13*a* ..	Do.	*Spirifera tasmaniensis*
13*b* ..	Do.	Spirifera sp.
14 ..	Do.	Mourlonia sp.
16 ..	Par. Walloon, Dawson River, 40 miles N. of Taroom	Crinoid stems
16 ..	Delusion Creek, 3 miles E. of Dawson River ..	do.
17 ..	Par. Walloon, Dawson River, collected by E. L. Peart	Spirifera sp. Mourlonia sp. *Murchisonia carinata* Productus sp.
18 ..	3 miles W. of Wealwandangie, 40 miles S. of Springsure head station	*Zaphrentis ? cainodon* *Z. robusta* Spirifera sp.
19 ..	Do.	*Strophalosia Clarkii* Productus sp.
21 ..	Do.	*Productus brachythærus* *Strophalosia Clarkii* Stenopora sp.
22 ..	Do.	*Strophalosia Clarkii* *Productus brachythærus* Stenopora sp. *Stenopora tasmaniensis* *Orbipora ? Waageni* *Murchisonia carinata*
23 ..	Wealwandangie	Zaphrentis sp. Stenopora sp. *Strophalosia Clarkii*
26 ..	Dilly, N. of Springsure	*Protoretepora ampla*
27 ..	In glacial conglomerate, Dilly, Springsure ..	*Eurydesma cordatum*
28 ..	Dilly, Limestone	Stenopora sp.
29 ..	Dilly, 7 miles N. of Springsure	*Strophalosia Clarkii* Stenopora sp. Polypora sp.
30 ..	Do.	*Productus brachythærus* *Stenopora ? Jackii*
31 ..	Dilly, 3 miles N. of Springsure	*Platyschisma oculus*
32 ..	2 miles N. of Dilly, Springsure District	*Deltopecten illawarrensis ?*
33 ..	Dilly, 7 miles N. of Springsure	*Stenopora Jackii* Productus sp. *Fenestella internata* *F. fossula* *Protoretepora ampla*
34 ..	Dilly	Zaphrentis sp. Stenopora sp. *Strophalosia Clarkii* *Productus brachythærus*
35 ..	2 miles N. of Dilly, Springsure, Minerva road ..	Stenopora sp. *Productus brachythærus* *Strophalosia Clarkii*

The following fossils, collected mainly by the late Mr. James Smith, official collector of the Queensland Geological Survey, have previously been recorded from the Dilly belt, north of Springsure, and have been diagnosed by the late Mr. Robert Etheridge, junr.:—

Aviculopecten sp.

Crinoids sp.

Eurydesma sp.

Fenestella sp. (between Dilly and Crystal Creek).

Productus brachythærus (two miles north of Dilly).

Protoretepora ampla var. *Woodsii* (two miles north of Dilly).

Protoretepora sp.

Rhombopora sp.

Stenopora australis.

Stenopora gympiensis (two miles north of Dilly).

Stenopora ovata (between Dilly and Crystal Creek).

Strophalosia Clarkii.

Productus subquadratus (between Dilly and Crystal Creek).

Productus cora, P. subquadratus, Stenopora gympiensis, and Rhombopora are typical of Carboniferous localities in New South Wales and Queensland.

All of these occur in the Middle Bowen (Marine) Series of Dr. Jack at Pelican Creek, Bowen, and all except *Productus cora* are recorded for Dilly in the above list, where in addition we have Eurydesma, another Carboniferous form. The writer's collection proves this Eurydesma to be *cordata*—Upper Kuttung—and it is accompanied also by *Aviculopecten Mitchelli* (Carboniferous).

It is evident that the Dilly Eurydesma beds have so much in common with the Pelican Creek Marine Series at Bowen, that it becomes a matter of strong probability that the equivalent of the Bowen Coal Field (Pelican Creek) coals should be found north of Minerva, and that the Pelican Creek Marine Series should, in spite of Eurydesma not yet having been recorded from them, be classed as Lower Marine. In that case the Collinsville coals cannot be the equivalent of the Greta, but must be the equivalent of the Carboniferous. This opinion is advanced tentatively.

The Marine fossils collected by the writer were examined by the late Mr. Willcox, and can be grouped as follows:—(A) from Lower Marine localities; (B) from Upper Marine localities.

(A) Collecting was confined to one spot on the Emerald road seven miles north of Springsure, two miles north of Dilly. The matrix is a calcareous mudstone, interbedded with sandstone.

(B) The Upper Marine localities comprise Buckland Creek, Black Alley Peak, and Wealwandangie Station.

Productus cora and *Protoretopora ampla* are also found and described by Mr. Dunstan in the Lower Marine at or west of Chine Bluff. This serves to correlate the Chine Bluff locality with Dilly and Pelican Creek. The Bowen coals are therefore below the Lower Marine of Mr. Dunstan.

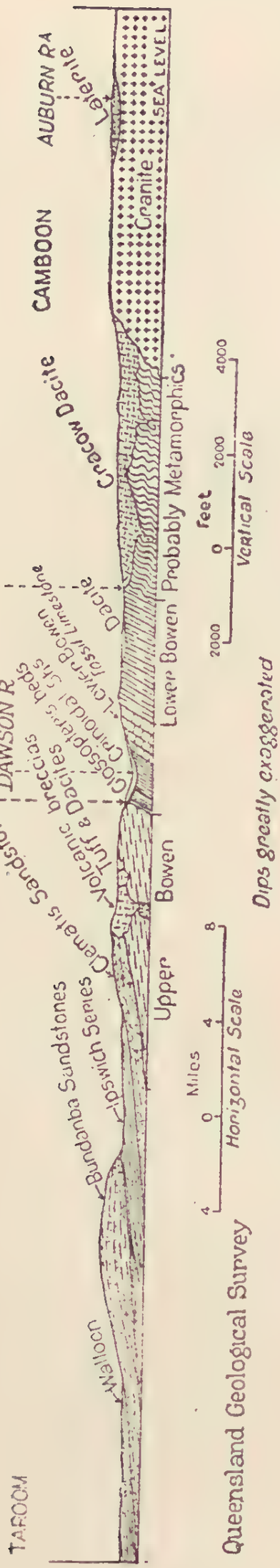

FIG. 13.—Section from Taroom to Auburn Range, illustrating structure.

PART D.— GEOLOGY OF THE TAROOM DISTRICT.

(*See* Plates III. and IV.)

I.—PHYSIOGRAPHY.

The country dealt with in this section embraces the Juandah and Taroom districts, the country between the Dawson Valley north of Taroom as far as the parish Walloon, and east to Auburn River, in addition to which one of us (Mr. Dunlop) has traversed the country between Auburn and Chinchilla, enabling us to extend our observations thus far.

Along the railway line from Miles to Juandah the country is uninteresting, gently undulating, consisting principally of sandy country, with isolated belts of brigalow-belar, as we find to be usually the case in the Upper Walloon formations. Prickly-pear has a firm hold of the better stretches of this country. The Dividing Range, which is crossed a few miles south of Juandah, is just, as in the case of the Dividing Range north of Roma, hardly noticeable, being merely a low water-parting. North of the Dividing Range the country is predominantly covered with brigalow and belar and prickly-pear, such country extending practically all the way from Juandah to Taroom. It is gently undulating and has the usual yellow clay-bank soils characteristic of the calcareous sandstones and shales of the Middle and Lower Walloon.

From Taroom northwards as far as Murphy Range, Lower Palmtree head station, we still have nothing but brigalow-belar-wilga scrub on rich black soils of the Lower Walloon character. This class of country extends westerly, as we have already seen in Part C as far as Broadmere. East of Taroom it extends as far as Marklands.

North of Lower Palm-tree head station we pass into ridgy country with yellow sandy soils, country of the open forest type with box, silver-leaf ironbark, and sandalwood, and a little blackbutt (*E. Cambagei*) in places. Minor patches of brigalow-belar country also occur. This sort of country, characteristic of the Basal Walloon, extends northwards for about five or six miles, when about eighteen miles from Taroom we pass into a different type of country consisting of poor sandy, silicious soils similar to those of Glenhaughton; here we have pine (*Callitris glauca*), narrow-leaf ironbark (*E. crebra*), bloodwood (*E. corymbosa*), quinine (*Petalostigma quadriloculare*), wattle (*A. Cunninghamii*), Moreton Bay ash (*E. tesselaris*), sugar-gum (*Angophora lanceolata*), bull oak (*Casuarina torulosa*), and similar poor-country vegetation. The Bundamba sandstone belt, which we are now on, extends northwards to the Coorada boundary, taking in most of Gwambagwine and Ghinghinda Stations, but there are belts in it of slightly better quality in soil and vegetation than the average. The first of these belts is met with at the 26-mile on the telegraph line north-north-west of Taroom about seven miles from Gwambagwine. This belt consists of a red sandstone with intercalated ironstone and ferruginous shale-bands, and corresponds in geological position and general character to a similar belt met with south of Baffle Creek. On this belt we have brigalow-belah scrub and associated vegetation. Again, about six miles north of Gwambagwine where the road crosses Palm-tree Creek, we have a better class of Bundamba sandstone country clad with silver-leaf ironbark and Moreton Bay ash. Near the Coorada boundary, about forty-eight miles from Taroom, we pass into spotted-gum country; the soil is still sandy and gravelly, consequently most of the timbers mentioned for the Bundamba sandstone persist with the spotted gum. Soon we notice that sandy country alternates in east-west belts with clayey country of shale derivation, and as Coorada is approached, say about sixty miles by road from Taroom, the shale belts take on a red colour which, as we have noticed elsewhere, is rather characteristic of many of the shale beds in the Ipswich formation. These red soils support wattle (several species), spotted gum (*E. maculata*), yellow bloodwood (both *E. Watsoniana* and *E. trachyphloia*), narrow-leaf ironbark (*E. crebra*) &c., but no brigalow-belar scrub. There are also belts of basalt country also oriented east-west with silver-leaf ironbark vegetation.

The country rises steadily from Taroom to Coorada, which must be about 2,000 ft. above sea-level. The type of country which we have described as characteristic of Coorada extends easterly to Ghinghinda head station, and then swings south-east through Tualka to Spring Creek, while the Bundamba type of country to the south of the Ipswich belt swings round with it through Waterton to Glebe Station north-east of Taroom and Cockatoo Station east of Taroom, thence south-east through Bungaban and crosses the Auburn Range between the head waters

of the South Bungaban Creek and Warranna Creek, and from Warranna it extends east-south-east, taking in the whole of the Dividing Range from Roche Creek to as far as the head of Jarrah Creek. It should be remarked that at various places, no doubt horizons, in the Bundamba we get particularly poor belts of sandy soil with the woolly oak (*Casuarina inophloia*), boodgeroo (*Lysicarpus ternifolius*), stringybark (*E. eugenoides*?) Angophora-like variety), and yellow bloodwood and spinifex grass. On the Auburn-Chinchilla traverse, country of the Bundamba character extends to within ten miles north of Chinchilla, south of which, right to Chinchilla, the country is of the Basal Walloon type in soil and vegetation.

Reverting to the Ipswich belt, which at Coorada has very much the same characteristics as at the head of the Moolayamber, and which at Coondarra was found also to be similar to Coorada (spotted gum, narrow-leaf ironbark, molly box), we found this belt to take on specially peculiar features on Spring Station, Estramadura, and Cockatoo Stations. This country is very broken, due largely to the swift weathering of soft oolitic ironstones, which are enormously developed in the upper beds of the Ipswich, corresponding with the tuffy beds in the Bullaroo gorge. The oolitic ironstone country, both hills and valleys, is clad with brigalow-belar scrub and yields rich red soils that are far better grassed than is usual in Ipswich formation. The lower beds of the Ipswich formation, met with on Cabbage-tree Creek on Dawson Valley, have typical poor-country vegetation on grey soils ranging from clayey to sandy nature, due to alternation of clay shales with micaceous sandstones.

North of the Ipswich belt in the region of Dawson Valley we have a fairly rugged sandy range between Dawson Vale and Cracow. The formation here consists of massive sandstones similar to those which we met with north of the Carnarvon Range, down Bullaroo Creek, and in the Clematis Creek gorge east of Warrinilla. This belt, which extends from the Dawson River at Nathan's gorge near junction of Cracow Creek and Dawson River, north-west through the Isla and Gibbergunyah leases, constitutes very poor country timbered with spotted gum, molly box, boodgeroo, Angophora-like stringybark, woolly oak, ironbark (*E. decorticans*), and indeed a mixture of the poor-country Ipswich and Bundamba formation timbers; wattles and prickly bushes abound (as on the Hawkesbury sandstones).

North of the Cracow Range, on tufaceous and brecciated country forming the base of this formation, we get better country with brigalow belts. Soon after, on Ross Creek, we enter a complex of volcanic formations forming moderately rough country with silver-leaf ironbark vegetation. From Cracow Station, in a general north-by-west direction along the Dawson River, we have a belt of rich blacksoil country with brigalow overlying Permo-Carboniferous limestones. East of this belt, as shown on the map, we have a continuous belt of rough country

with volcanics similar to those of Cracow; and further east we have tablelands and rough ranges, spurs of the Auburn Range, consisting in the main of granite. The granitic country is forested with the ironbarks (*E. melanophloia, E. paniculata, E. crebra*), poplar gum, Moreton Bay ash, silky oak, &c. The granitic tablelands, which are residuals of a peneplain having about the same level as the sandstone tablelands west of the Dawson, have their granite superficially decomposed to a laterite for up to 40 ft. in depth. This laterite in many places simulates sandstone. Where derived from rather silicious granite we have it covered with a Desert Sandstone flora, consisting of budgeroo (*Lysicarpus ternifolius*), Angophora-like stringybark (*E. eugenioides* var.), woolly oak (*Casuarina inophloia*), lancewood (Acacia), and numerous wattles (*Acacia polybotrya, A. Cunninghamii, A. conferta, A. lunata,* &c.); but in other places where the granite is more basic the laterite is extensively covered with molly box (*Eucalyptus rariflora*), while dioritic and andesitic belts in it have brigalow and belar scrub. Spotted gum also occurs on some of the laterite country near Rockybar and Auburn. Other patches of granite and laterite have ironbark and poplar gum flora.

Mr. Morton has been through from Auburn to Hawkwood and thence to Rawbelle, and found the whole of this stretch to consist of granite and laterite with similar soils and flora to those described.

We were informed by station people in the Auburn Valley that the country is practically all the same, as described above, as far east as Mundubbera.

The granite areas of the Auburn drainage system are rather remarkable for their level nature, which is an indication of peneplanation prior to Mesozoic deposition.

II.—GEOLOGY.

The geological formations represented in the area under review range from Ancient Palæozoic to Tertiary in geological age. North of the Dividing Range in the Auburn drainage area we have a complex consisting, as already mentioned, mainly of granites intruded by intermediate and basic lavas, but here and there between Auburn and Hawkwood we get knotted mica schist included in the complex. This complex has undergone repeated uplifts, so that it is flanked unconformably on its western side with Lower Marine strata from Cracow northwards east of the valley of the Dawson. These Lower Marine beds are unconformably overlain by the Mesozoic beds commencing with the Clematis series. A volcanic period inaugurated the Mesozoic sedimentation. Dacitic and rhyolitic lavas have broken through the Marine strata and underlie the Clematis sandstones, which commence with tuff and breccia beds. The Clematis sandstones pass conformably into the Ipswich, over which we have in regular and conformable succession the Bundamba series and the

Walloon. North of Coorada the succession has not been investigated yet, but there is reason to believe that here we would find all the Permo-Carboniferous beds under the Clematis in conformable succession, as is the case in the country north of the Carnarvon Range and Clematis Creek gorge.

Mr. Hocky, who was drilling sub-artesian bores at Coorada, and has been drilling on Bauhinia Downs, Punchbowl, Roundstone, and Gibbergunyah, stated that bores on these stations are mostly in blue mudstones and shales, which are characteristic Upper Bowen Coal Measure rocks. One bore on Punchbowl passed through a 15-ft. coal-seam. Near the Gap (Gibbergunyah) on Glenmoral Station, Mr. Hocky states there is a very salt spring; and Mr. F. Bennett, who knows this district very well, also confirms that salt water is a characteristic of the Highworth country. This is what would be expected in the Upper Bowen marine formations, which are very saline. The entire series forms a monocline sloping to the south and south-west, which has been folded somewhat at right angles to the general dip of the whole series.

The most striking subsidiary structure is a north-south synclinal trough passing through Juandah and Taroom. On the east of this dips are much steeper than on the western side. The strata rise in the form of an anticline over the Auburn Range, from which they have been eroded in part. The swing of the strata indicates the existence of a minor anticlinal fold on a north-south direction through Glenhaughton and Reedy Creek and Bauhinia, while a considerable syncline is indicated along the axis of the Expedition Range from Bedourie northward.

Tertiary and Post-Tertiary.

Alluvials of Post-Tertiary age occur to considerable depth along the valley of the Dawson, as illustrated by the bore-hole put down by the Government for a foundation for a dam near the junction of the river and Delusion Creek. These bores passed through 80 ft. of river silt. Similar alluvials occur in many mountain pockets, but are of no geological importance.

Tertiary beds occur as small pockets in places, as, for instance, nine miles east of Camboon woolshed on the Dawson, halfway between that outstation and Camboon head station, where we have a small Tertiary pocket of sandy mudstone on Oxtrack Creek. On this formation we have brigalow-wilga scrub and a soil very similar to the Walloon soils. This rock is built up of the wash from granites, tonalites, and dacites, which occur all around, and the similarity of its soil and flora suggests that the Walloon formations are largely of similar derivation.

The existence of Tertiary volcanic rocks has not been proved in the Dawson Valley, but the Bigge Range is to the north of Coorada and also Coorada itself, bespattered with lavas of basaltic character, which are probably Tertiary. There are certain features

in the lay of these lavas which suggest interbedding with the Ipswich. Thus, the basalts are generally found on the gentle southerly slope of east-west ridges, which, as a rule, slope more steeply to the north. Since, however, the drillers have not met with any basalt in the bore-holes, it is more likely that the basalt is Tertiary.

Cretaceous.

No Cretaceo-Tertiary or Cretaceous formations were met with in this area.

The Walloon (Jurassic).

The Walloon formations in this area have the same general characters as in the country north of Roma. Outcrops are so few and the country so prickly-pear infested that the detail work of mapping the boundaries between the stages of the Walloon was not attempted, but, on the evidence of the vegetation and of information regarding wells and coal-seams, an approximation has been made.

Coals of a Walloon character occur in many wells in the Taroom district. A sample from a seam 4 ft. thick, situated on Kehl's selection, "Happy Home," four miles south-east of Taroom, gave an analysis:—

	Per cent.
Moisture	2·7
Volatile hydrocarbons	46·5
Fixed carbon	43·6
Ash	7·2

Another sample, from Medhurst's selection, north of Taroom town, yielded—

	Per cent.
Moisture	4·0
Volatile hydrocarbons	37·1
Fixed carbon	44·2
Ash	14·8

The nature of the soils and of such rock exposures as occur between Taroom and Juandah show the whole of that country to be Calcareous, or Lower Walloon. Coal occurs on Roche's Creek near Rochedale Station, and in small seams on portions 1v and 14, parish Juandah; on portion 16, parish Wandoon; on Weringa Creek there is a 2 ft. 6 in. coal-seam; 9 in. of coal on portion 36, parish Jerrard; and a 6-ft. seam in a well with very salt water at 30 ft. in the parish Cherwondah near Gulugura.

These coals are all probably Lower Walloon. The shales and sandstones lie very flat in the area in which these coals have been recorded.

The Dividing Range about twenty miles north of Miles is very nearly the boundary between Middle and Lower Walloons on the railway. South of this divide, country of the open-forest

type predominates, and thirteen miles north of Miles we have the Middle Walloon petrified-wood horizon. Miles itself is on Upper Walloon sandstone.

The northern boundary of the Lower Walloon extends from the junction of Eurombah Creek and the Dawson River in a direction north-north-west to portion 3v, parish of Broadmere; then east-north-east to Lower Palm-tree Station; and from the junction of Palm-tree Creek with Broom Creek the boundary again swings to the south-east to Marklands, about ten miles east of Taroom, thence in a south-south-east direction. This boundary continues practically parallel with the boundary of the Basal Walloon and the Bundamba, hitting the railway line near Chinchilla.

The boundary between the Basal Walloon and the Bundamba in the Taroom district is generally met with five or six miles from the boundary just mentioned. It occurs to the west of Taroom a few miles to the west of Broadmere, and extends east-north-east to intersect Palm-tree Creek about six miles north of Palm-tree head station; it then takes on a south-east direction and we get it about Bentley Creek, parish of Cockatoo.

The Basal Walloon consists of massive yellowish felspathic sandstones which are easily distinguished from the Bundamba sandstones by their more clayey soils, frequent yellow clay-banks in the creeks, and a type of vegetation indicative of fair country.

The Bundamba Sandstones.

The Bundamba sandstone belt as shown on our map extends in the Taroom district over most of Glenhaughton and Gwambagwine Stations and over a large part of Ghinghinda, whence it swings south-east through Waterton and on to the Dawson River at the Glebe Station, and then across Cockatoo Station to the Auburn between the head of Spring Creek and the Dividing Range. Thence along the Dividing Range as far as the Auburn-Chinchilla road we have Bundamba sandstones, but this formation extends south to within ten miles of Chinchilla. The dips of the Bundamba sandstones are much steeper, on the whole, round the Taroom embayment of the Walloon basin than north of Roma. At the 26-mile post on the telegraph line from Taroom to Bauhinia, a dip to the south of 5 deg. is well marked. About one mile to the north of Gwambagwine a dip to south-south-east at 15 deg. occurs on the road, but it flattens to 5 deg. in a short distance. Where the Coorada road crosses Palm-tree Creek the dip is south-south-east at 5 to 6 deg. The dips in the Bundamba series to the east of the axis of the Taroom syncline are steeper, ranging from 5 to 10 deg. and averaging probably 8 deg.; about five miles south of Ghinghinda a dip to the south-west at 10 deg.; about half a mile south of Glebe Station a very general dip at 8 deg. to the west was noticed. On Cockatoo

Station along Bentley Creek the massive sandstones were dipping to the west at 4 deg. Near Bungaban a general south-west dip was noticed, and near the head of Roche Creek the sandstones were seen to dip west-south-west at 10 deg.

Then in the wide belt of Bundamba sandstones south of the Dividing Range to the north of Chinchilla the stratification is very flat. The highest dip noticed north of Chinchilla was near the boundary of the Ipswich formation on top of the Dividing Range where a dip 10 deg. west of south at 5 deg. was recorded. Large permanent lagoons and waterholes are a feature of the Bundamba belt. Springs are also frequent, and on Glebe Station mound springs of great size occur.

Ipswich.

The Ipswich formation conformably underlies the Bundamba along its entire extent in this area. It covers Reedy Creek and Coorada Station and northern portions of Ghinghinda, Spring Creek Station, and Spring Station, parts of Dawson Vale and Cockatoo, and crosses the Auburn Range at the head of Redrange Creek, whence it has been traced easterly as far as shown on the map. As far as the Auburn Range the Ipswich formation conformably overlies the Clematis sandstone, but on the Burnett waters the Ipswich formation lies unconformably on an eroded granite mass.

The rocks entering the Ipswich formation at Coorada are gritty sandstones, silicious fine-grained sandstones of rather micaceous nature, white clay shales and red shales. The last mentioned are similar to and yield the same kind of red gravelly country as the red shales on Spring Creek in the Carnarvon Range. The white shales decompose along watercourses to yellow clay-banks or mottled red-white clay-banks similar to those common in the Brisbane Valley. In the Auburn district the shales of Ipswich age are also similar to those of the Brisbane Valley.

There is, however, a stretch between the Dawson River at Spring Station and the Auburn Range at the head of Redrange Creek where a novel rock type appears in the series, viz., oolitic ironstone, which forms thick and extensive masses on Spring Station, Dawson Vale, Estramadura, and Cockatoo. Interbedded with the oolitic ironstone we get white silicious shales and bluish tuffy shales. In some of the white shales we obtained obscure fossils, mostly Equisetites stems, but also fragments of *Cladophlebis sphenopteris* and *Equisetites rotiferum*, none of which can be said to be distinctively Triassic, but the position of these rocks under the great Bundamba series is sufficient to determine their Ipswich age.

The oolitic rock, above mentioned, we are at present inclined to consider to be derived from ferruginous tuffs, this opinion

being based on their passage into tuffs similar to those on the Moolayamber and not unlike many that occur in the Esk series, Brisbane Valley. This area is probably one in which spasmodic volcanic action continued from the beginning of the Mesozoic to the end of the Ipswich period. A search was made for fossils in the oolites, but none could be found. In the Auburn Valley, Mr. Dunlop noticed ferruginous clay outcrops in many places along Spring Creek and Johnson Creek. These clays lie very flat and are vertically jointed, and are probably a Tertiary lateritic formation derived from the near-by granite, and not to be included in the Ipswich series of the same belt.

Rocks of Ipswich age on Coorada dip gently to the south. At a sub-artesian bore ten miles east by south from Coorada head station, shales dipping south-south-west at about 8 deg. were noticed. Here too there was evidence of a fault dipping west at 45 deg. The country rises fairly rapidly as we proceed north from Palm-tree Creek to Coorada, and having an east-west strike with a dip to the south we repeatedly ascend a long shelving hill, sloping south, and descend a short steeper slope into a gully. The gentle southerly slopes have usually a reddish gravelly soil and coincide with ferruginous shale beds; the short, steeper slope is sandy and shows sandstone outcrops. Some of these ridges have the southern gentle slopes basalt-capped, suggesting an interbedding of the basalt, which, for reasons already stated, cannot be entertained. At Ghinghinda Station the Ipswich shales dip south-west at 10 deg. On Dawson Vale homestead we have alternate sandstones, gritty conglomerate, and shales (red and white), dipping west and south-west at low angles. In a road cutting (Cracow road) near Downfall Creek, approximately the boundary between the Ipswich and Clematis series, we have a south-south-west dip between 5 and 6 deg. At the head of Downfall Creek, Ipswich strata were dipping south-west between 3 and 4 deg. Over the Auburn Range, where this formation lies unconformably on granite, the dips are rather disturbed, especially on Pigott Creek, no doubt due to lateral compression in confined valleys in the eroded granite. The general direction of dip, however, is to the south, especially near the Bundamba boundary.

No coal-seam of any consequence has so far been reported in this series to the north of Taroom, but in the Auburn basin on portion 20 parish Coondarra two seams respectively 1 ft. and 2 ft. 6 in. were met with in a well at about 50 ft. associated with brackish water. This coal gave the following analysis:—

	Per cent.
Moisture	3·9
Volatile hydrocarbons	37·1
Fixed carbon	44·2
Ash	14·8

The Ipswich strata throughout this area are very micaceous,

indicating derivation from sediments which have been transported from granite areas. This is somewhat confirmed by the abundance of molly box both on many areas in the Ipswich belt and on the lateritic granite of the Auburn Range.

Clematis Series.

Underlying the rocks of the typical Ipswich facies, we have a large formation of coarse silicious sandstones aggregating in this district over 1,000 ft. in thickness, but estimated further west on Bullaroo Creek at about 2,000 ft. This formation appears to be the equivalent of the Borallon series of the Brisbane Valley. This conclusion is drawn mainly from the fact that the Ipswich rocks lie conformably on the Clematis, and the fact that both the Borallon and the Clematis formations commence with a volcanic cycle in which dacitic lavas were predominantly erupted. The sandstones of Gibbergunyah and Isla belong to the Clematis series, as do also those of Nathan's Gorge, the site of the proposed irrigation weir. From Nathan's Gorge the formation sweeps east-south-east along Cracow Creek through the northern portions of Dawson Station, forming the dividing spur between Dawson Vale and Cracow, cutting out in the Auburn Range at the head of Downfall Creek, where it unconformably overlies granite except where basalt tuffs and dacite lavas intervene. On the northern side of the Cracow Range the Clematis sandstones are agglomeratic, at the base passing into volcanic tuffs and breccias which overlie dacitic and rhyolitic lavas. These lavas rest on (and have broken through as dykes and necks) Lower Marine limestones along the Dawson Valley and an old granitic complex further to the east near Camboon and the Auburn Range. Since the Lower Marine series on the Dawson is dipping at high angles to the west, while the Clematis sandstones are dipping at angles of only 5 deg. and under to the south-west, it is obvious that there is a big unconformity between the Lower Bowen and the Clematis series in this region.

At Downfall Creek the top of the Clematis series dips in a south-by-west direction at between 5 and 6 deg. On top of the Cracow Range the dip is still a little west of south at between 4 and 5 deg. On Ross Creek side of the Cracow Range, where the sandstones commence to pass into breccia, south-south-west dips at 5 to 6 deg. were noted. At Nathan's Gorge the series lies very flat with a tendency to gentle south-west dip. This is more noticeable at Price's Creek. On the Auburn Divide between Rocky Bar and Estramadura (head of Downfall Creek), the Clematis almost completely cut out, and what is left of them, lying upon dacites and granites, dip south-west at 3 to 4 deg. in under typical Ipswich beds.

As already mentioned the Clematis sandstones have a calciphobe vegetation not unlike that of the Bundamba series.

East of Auburn Range the Clematis series does not seem to have been deposited at all, the Ipswich rocks here lying direct on the granite.

Lower Marine.

While the Mesozoic formations of the Dawson Valley have a general south-west dip at low angles, the Lower Marines strike north-south and dip on the average due west at high angles. In the belt along the Dawson from Cracow Creek to Camboon woolshed, which is as far north as we proceeded along the river, the Lower Marine limestone series with some calcareous mudstones is the sole representative of the Bowen formations.

The limestones of this formation have undergone a considerable amount of metamorphism, several beds being very hard and crystalline. Dykes of dacite, andesite, and rhyolite break through the formation, and volcanic flows of the same kind frequently overlie the limestone, forming considerable hills. In the ridge about one mile west of Cracow homestead, the first limestones met with were striking at 350 deg. and dipping in a westerly direction at 20 deg. Three chains further west the dip steepened to 45 deg., and on the top of a hill there was a reversion yielding a south-east dip at 25 deg. At the foot of the hill on the west side we noticed calcareous mudstones dipping north-west at 15 deg. and crossed by a rhyolite dyke. These dips show considerable contortion immediately west of Cracow homestead. The highly calcareous nature of the gilgai-brigalow scrub areas on the Ipswich formation at the head of Downfall and Cabbage-tree Creeks is strongly suggestive that the marine strata exist here at no great depth below the Ipswich capping. From Cracow north to Delusion Creek the general strike of the marine rocks is 350 deg. At Orange Creek, strike 350 deg., dip west 10 deg. south at 25 deg. The same strike continues as far as Oxtrack Creek with a dip to the west at 30 deg. Several strong undulations occur in the strike near Oxtrack Creek, where south-west and south dips were noted at angles ranging from 25 to 45 deg. Massive limestones of this belt are about two miles wide in surface outcrop. Overlying them on the west side we have crinoidal mudstones and shales. The rocks underlying them are for the most part obscured by volcanics, but about three miles east of Camboon woolshed some small outcrops of yellow shale were seen which may belong to the series underlying the marine formation.

The marine limestones contain considerable thicknesses of pure limestone, which should be of great utility in the manufacture of cement for the dams and weirs contemplated in connection with the Dawson River irrigation scheme. The close proximity to the limestones of Ipswich shales and varied volcanic tuffs is a guarantee that there must be abundant clays in the district suitable for the same purpose. The distance from the Cracow limestones to Nathan's Gorge is less than twelve miles, while limestone exists right alongside the Delusion dam site. The

Lower Marine limestone belt is extremely prolific in fossils. The list of species collected by us, as recorded below, will be seen, on comparison with the list given by Mr. Dunstan as collected by him in the Banana district, to be typically Lower Marine and to have an Upper Carboniferous bias. In lithological character, hardness, and metallic ring when struck by a hammer, these limestones are similar to those of Dilly near Springsure, and those of Pelican Creek on the Bowen coalfield, and differ notably in physical characters from the soft yellow limestones of the Upper Bowen.

List of Marine Fossils collected along the Dawson.

Stenopora sp.
S. Jackii
S. crinita
S. gympiensis
Also "frondescent" Stenopora encrusting crinoid stem
Zaphrentis sp.
Z. Gregoriana
Platyschisma oculus and Mourlonia
Fenestella fossula
Productus subquadratus
P. brachythærus
Productus sp.
Trachypora sp.
T. Wilkinsoni
Crinoid stems
Martiniopsis subquadrata
M. Strzleckii
Spirifera duodecimacostata
S. Strzleckii
S. tasmaniensis
S. convoluta
Aviculopecten sp.
Cyathophylloid corals sp.
Cyathophyllum sp.
Monticulipora sp.
Polypora.

In many places the fossiliferous limestone is strongly chalcedonised on the surface. The presence of *Chonetes cracowensis* (early records), the almost complete absence of Strophalosia, and the abundance of Carboniferous Productidæ make the assemblage of fossils, even in the absence of *Eurydesma cordata*, take on a Carboniferous facies.

The Auburn Range Complex.

East of the volcanic masses which have broken through the Lower Marine and which cover up the junction between the Lower Marine and underlying beds in this district, we have a complex of plutonic rocks embracing granite, tonalite, diorite, aplite, graphic granite, and pegmatite, as well as completely recrystallised sedimentaries, which show as aplite-looking quartzites near Camboon. Further to the south-east at Auburn, patches of schist, including knotted schist, having a more definite sedimentary appearance, occur in the complex. Dykes of andesite and dacite traverse this complex, and flows of dacite lie on the granite in the Auburn Range between Cockatoo and Rockybar.

Concerning the relative ages of the igneous rocks of the complex we can say nothing, except that the dacites are the last. At Rockybar there were dykes of dacite through the granite.

The soils are very variable, depending on the chemical composition of the parent igneous rock, and the vegetation is likewise variable. On dacite ridges and hills we have silver-leaf ironbark (*E. melanophloia*) and the narrow-leaf (*E. crebra*); on flats in the dacite country, poplar box (*E. populifolia*). On a large tonalite flat about three miles west of Camboon Station we have Moreton Bay ash (*E. tesselaris*), red gum (*E. tereticornis*), poplar box, and silver-leaf ironbark, as well as silky oak (*Grevillea robusta*), red ash (*Alphitonia excelsa*); and on much of the dacite and tonalite tablelands near Camboon as well as on many of the good dioritic granite areas near Rockybar we have great forests of the more coastal ironbark (*E. paniculata*). On some of the graphic granites a little wilga-sandalwood scrub was noticed, while on the diorites and andesites which cover many miles of country south of Camboon we had brigalow-wilga scrub. About twelve miles south of Camboon on the Rockybar road we first entered a class of formation which is very widespread on the granite areas between the Auburn Range and Mundubbera, viz., the laterite.

Laterites in this area are formed by the decomposition of granite *in situ*. Red laterites with a fair soil and fair country vegetation are developed on the more basic granites, and whitish sandstone like laterites on the silicious granite. Molly box (*E. rariflora*) was the dominant timber of the better class of laterite, but on the silicious laterite we have a vegetation suggestive of Desert Sandstone, including stringybark (*E. acmenioides*, Angophora-like variety), gumtop ironbark (*E. decorticans*), peppermint (*E. exserta*), boodgeroo (*Lysicarpus ternifolius*), woolly oak (*Casuarina inophloia*), hill oak (*Casuarina Luehmani*?), and a number of wattles, including *A. Cunninghamii*, *A. polybotrya* var. *foliosa*, *A. conferta*, &c.

The origin of these laterites is similar to that of laterites described by Mr. E. C. Saint-Smith (Q.G.M.J., Sept. 1921, p. 359, Lateritic Deposits near Charters Towers), and by myself in the Myilly Point Cliffs near Darwin (Bulletin of Northern Territory, No. 10).

PART E.—THE TAMBO-BARCALDINE DISTRICT AND SUPPOSED OIL MANIFESTATIONS OF THE ENNISKILLEN RANGE.

I.—INTRODUCTION.

During January and February 1922, the writer went to Tambo to report on supposed oil indications at Macfarlane Downs, and took the opportunity to visit Caldervale, Mount Playfair, and other portions of the Great Dividing Range, in order to determine what happens in a westerly direction to the formations diagnosed north of Roma and Mitchell. The results of the work done are incorporated in the Geological Map (Plate I.).

II.—GENERAL GEOLOGY.

The Central Western line crosses the Drummond Range in the heart of the Lower Carboniferous Star formation. At Pine Hill the Star formation becomes covered up by an overlap of Desert Sandstone (Cretaceo-Tertiary), and from the train one can see very little of any formation but the Desert Sandstone between Pine Hill and the Barcaldine woolshed about six miles east of Barcaldine. In places between Pine Hill and Alpha one may notice a bouldery surface suggesting proximity to the surface of the Lower Bowen conglomerate. In a cutting on the Dividing Range a white, compact-bedded sandstone dipping at angles up to 10 deg. shows for a few hundred yards. This is about ten miles west of Alpha and is probably Permo-Carboniferous. Coal has been met with in bores around Alpha, probably Permo-Carboniferous, in this instance Middle Bowen, and probably contemporary with the coal said to occur at the head of Alpha Creek. Near Alpha Station coal is also said to occur, and if it is so it would be on the line of strike of the Upper Bowen coal measures which swing through Nardoo, Mantuan Downs, and part of Castlevale Stations. This belt probably crosses the Central Railway under a Desert Sandstone cover between Beta and Jericho.

A good collection of Upper Bowen crinoids and shells was shown to me in Tambo, collected in the foothills of the Castlevale Range, twenty-five miles by road from Mantuan Downs, and about halfway between Castle Vale and Mantuan Downs Stations. The high ranges of Castlevale facing Goodliffe Creek are composed of Bundamba sandstone..

In the Coreena bore about eighteen miles north-north-east of Barcaldine, Walloon coal was passed through at a depth of 700 ft. The parts of the Enniskillen Range (Warrego Range) inspected to the west of Tambo show that range to be made up of the so-called "Desert Sandstone," in this region consisting

of interstratified more or less lenticular beds of conglomerate, sandstone, and mudstone which rest horizontally on the more or less gently undulating folds of the Cretaceous Marine.

Barcaldine, Blackall, Tambo, Nive Downs, and Augathella are situated on the outcrop of the Cretaceous marine fringing the Walloon formations on the west. To determine the width of the Walloon formations between Tambo and the Carnarvon Range, and to gain personal knowledge of the geology of this part to complete my work on the Carnarvon Ranges, I went from Lansdowne to Mount Playfair.

A few miles (about two miles) east of the junction of the Nive River and Stockade Creek on the Caldervale road we got on to the silicious sandstones of the Upper Walloon. For a width of ten miles on an east-west line we have open forest country, often sandy and gravelly, overlying conglomerates, shales, and silicious sandstones of the Upper Walloon. The character of the country is very analogous to the country between Minka and Yingerbay on the Roma-Orallo line. About five miles west of Caldervale a calcareous sandstone shale series commences, with belts of brigalow scrub similar to the Orallo country. We run out of this about five miles north and west of Caldervale, and once more get a silicious sandstone analogous to that occurring on the Dividing Range north of Roma between the Orallo and Injune coal measures. West of this belt, which is only three to four miles wide, we have a wide brigalow zone surrounding Mount Playfair, which corresponds in soil, rock, and vegetation with the Toolumbilla, Womblebank, and Injune Creek country. Mount Playfair is the remnant of an old crater or fissure from which basalt flowed. It is basalt-capped and about 2,300 ft. high. The Walloon rocks occur to a height of about 2,000 ft., and between them and the lava we see a gravel bed of Cretaceo-Tertiary age.

Tertiary Rocks.

The basaltic effusions have been much more circumscribed in this area than in the Carnarvon Ranges of the Buckland region. Their Tertiary age is shown by their superposition on gravels analogous to those so common in the Desert Sandstone. Standing on Mount Playfair it is easily seen that the high peaks north and east of Mount Playfair are also basalt-capped, but the intervening country is Walloon or older. The white Bundamba sandstone cliffs can be seen to the north beyond Playfair homestead and north-east beyond Lake Salvator.

Desert Sandstone.

On some of the older geological maps of this State a large area of the country forming the Dividing Range east of Tambo is shown as "Desert Sandstone." This is incorrect, and the mistake is due to the confusion of Walloon Sandstones with Desert

Sandstone. It is perfectly true that there are isolated, disconnected tableland cappings of Desert Sandstone on some of the Walloon as well as on Cretaceous marine areas. A capping of true Desert Sandstone is never to my experience found at elevations of more than 1,800 ft. Gravels of similar nature to those found in the Desert Sandstone are sometimes found higher, under basalt.

The Desert Sandstone is always a loosely cemented, variable formation; sometimes it is sandstone weathering with a jagged surface covered with projections and holes, some of which are reddish and some white, giving the rock a mottled appearance. There are no proper bedding planes visible, but we often have irregular partings in different directions, a crude jointing similar to that seen in cracking sundried mud or in black soil in dry seasons. These mudstones are likewise unstratified and crudely jointed. Surface silification often changes the top layer into a cherty "billy," which, however, cracks in all directions, and does not weather into round boulders like the typical "billy." Both in the sandstones and in the shales one may meet with beds of conglomerate, consisting largely of quartz and volcanic pebbles (of Permo-Carboniferous age) and pebbles or boulders of "billy" with more or less opalised wood. The deposition of these conglomerate beds enables one to say definitely that the Desert Sandstone is practically a horizontal formation and has no stratigraphical relation to the underlying beds. It rests quite unconformably on the older formations. If it has any tilt at all, it can only be judged from the gradual fall in elevation of the base of the Desert Sandstone cappings as we go west. Thus at Caldervale the cappings rest at a height of 1,600 ft. on the Walloons, but at Charleville, about eighty miles away, we find the same formation commencing at 1,000 ft. or thereabouts, indicating a fall of 600 ft. in eighty miles or about 8 ft. in the mile, a dip so slight as not to be recognised by any instrumental means. The underlying Cretaceous Marine are folded sufficient for dips to be visible to the eye, and often to the extent of 5-deg. dips.

Through these characters the Cretaceo-Tertiary are easily distinguished from the Walloon formations, which show (1) distinct bedding, (2) a compact nature, and (3) easily observed definite dips in most places.

Even without any geological knowledge the bushman can generally pick the Desert Sandstone by its soil and vegetation. The Desert Sandstone is characterised by reddish loamy soil, while the Walloon sandstones have a grey sandy soil, and the Walloon shales black or chocolate clayey soil. The Desert Sandstone grows a variety of timbers, but the mulga (*Acacia aneura*), silver mulga, black mulga, and bendee are almost always interspersed and often form thick scrubs on it. The Walloon sandstones are characterised by an absence of mulga and the presence of pine, lancewood (*Acacia doratoxylon*), and ironbark (*Eucalyptus*

decorticans). The Walloon shales have brigalow (*Acacia harpophylla*) scrubs with belar (*Casuarina lepidophloia*) and myall (*Acacia pendula*).

In the Enniskillen Range we have at the base of the Desert Sandstone in places a boulder conglomerate of "billy." This "billy" has been formed by surface silicification in calcareous beds, both Walloon and Cretaceous, but has probably been redistributed by glacial action.

In addition to the Enniskillen Range and Warrego Range, which are Desert Sandstone divides, and the disconnected cappings mentioned in the spurs of the Main Range, we have Desert Sandstone forming the divides between many of the rivers. A large area of mulga country stretches south from near Caldervale to the vicinity of Augathella east of the Nive, between that river and the Warrego. I am informed that between the Nive and the Ward, and between the Ward and the Langlo, there are similar Desert Sandstone cappings on the divides. The present Desert Sandstone strips occupy the position of valleys in the old Upper Cretaceous land surface which preceded the depression that permitted Cretaceo-Tertiary sedimentation. As a long period of erosion is likely to have elapsed between the deposition of the Marine Cretaceous and the Desert Sandstone, it is probable that the valleys in the Upper Cretaceous land period occupied mostly anticlinal positions. If that can be fully established by later research—and my examination of bore records in the district under review points to the fact—the Desert Sandstone strips are in general in anticlinal positions.

The nature of the lower beds of the Desert Sandstone points to their deposition by sudden fitful melting of large ice-masses, and, as already stated in a previous report, some of the material in the "billy" mounds points to Upper Cretaceous ice action.

The Desert Sandstone period concluded with desert conditions leading to surface silicification, after which followed the wet period when large Tertiary lakes occupied much of our interior. A good sub-artesian water supply is generally met with at the base of the Desert Sandstone.

The Cretaceous Marine.

This formation occurs widely in the Tambo-Blackall area between the Desert Sandstone residuals. Owing to the general covering of black soil and the flatness of the country, the rock exposures are few and dips rarely obtainable.

At Macfarlane Downs homestead the formation consisted of calcareous sandstones with a very slight almost unnoticeable dip, to the north-west. About one and a-half miles west by south of the homestead a good dip to the south-south-west was seen in a gully at 3 deg. It would seem that the dips in the Cretaceous

Marine as in the Walloons are not regular, but undulating, forming terraces, though the average dip, as gauged from the artesian water supplies generally, is towards the south-west at a low angle, near 100 ft. to the mile at least along the edge of the Cretaceous basin.

The Cretaceous Marine formation is composed principally of impervious dark-grey or blue-black shales and fairly impervious calcareous sandstones. A few lenticular sand and gravel bands occur in the series, thus at the deepest of the "oil" bores on Macfarlane Downs a gravelly bed was encountered in the Marine series at 1,200 ft. This could only be the Walloon in case the Enniskillen Range occupies a strong anticlinal position in the Walloon Cretaceous, which is possible but not probable. Unfortunately we do not know what lies below 1,200 ft. in this bore, as it ended there. But at Minnie Downs bore nine miles to the south-south-east and at the Narramba bore sixteen miles to the south-east of Macfarlane, the first Walloon water supply comes in at 2,600 and 2,900 ft. respectively; and at the Macfarlane bore, only four miles north of the "oil" bores, the first Walloon supply came in at 2,300 ft. It is therefore probable that the Cretaceous Marine preserves an average south-west dip in this region in spite of gentle undulations locally altering this average dip.

The rocks of the Cretaceous Marine are in this area over 2,300 ft. thick. It is highly probable that originally they were 4,000 ft. thick as in the Winton area, but 1,700 ft. of sediments were removed here in the land period between the end of the Cretaceous Marine and the beginning of the Desert Sandstone deposition. This would make it possible for the Desert Sandstones in this area to be the equivalents of the Upper Beds of the Winton series, which overlapped the older rocks by degrees as the Cretaceo-Tertiary sea grew larger.

The Walloon Series.

The Upper Walloon rocks west of Caldervale differ from the Upper Walloon rocks north of Roma in some respects. They contain, for instance, frequent conglomerate beds with boulders up to several pounds in weight, and the sandstones themselves are more gritty. The boulders and pebbles in the conglomerates consist of quartz, slate, porphyry, and basic porphyrite, rhyolite, and trachyte (these volcanics being derived from the Lower Bowen eruptives) and clearly indicate derivation from Devonian and Lower Carboniferous rocks of the Drummond Range. The conditions of deposition were different from those in the Roma district, in that land cannot have been very far away and currents were strong.

The trees on the sandstones and conglomerates are the same as on the sandy belts north of Roma—viz., silver-leaf ironbark (*E. melanophloia*), narrow-leaf ironbark (*E. decorticans*), Moreton Bay ash (*E. tesselaris*), and in dry sandy places lancewood

(*A. doratoxylon*). On the clayey soils of the interbedded shale beds we get box (*E. populifolia*), and sandalwood (*Eremophila Mitchelli*). At the Rock Waterhole, on the Caldervale road, a dip to the west-south-west at about 3 deg. was very noticeable. At various points the dips were noticed varying from west to south-west at low angles.

The Middle Walloon rocks commence about five miles west of Caldervale. They are interbedded shales and calcareous sandstones overlain on the ranges by the silicious sandstones of the Upper Walloon; and the country is good pastoral country. The forest trees comprise box (*E. populifolia*), silver-leaf ironbark (*E. melanophloia*), brigalow (*A. harpophylla*) in thickets, wilga (*Geijera parviflora*), ironwood (*A. excelsa*), &c., as in the Orallo belt north of Roma. A general westerly dip is seen in places at low angles. In the hills about two miles north-west of Caldervale a brown shale was obtained with abundant fossil vegetation, chiefly *Tæniopteris spathulata* and Neocalamites, representing the top bed of the Middle Walloon, the silicious sandstones being immediately on top. Throughout the Caldervale belt of country we have an abundance of petrified wood (silicified) bestrewing the surface. This links up Caldervale with Redford, Forest Vale, Orallo, and the whole of the Middle Walloon belt.

About four miles east of Caldervale we have the sandstone belt which underlies the Orallo coal measures. It is rather more conglomeratic than in the Roma-Injune area.

Indications of coal have been met with in the shallow bores about Caldervale, but no large seams have been passed through.

About four miles south-west of Mount Playfair we enter the Lower Walloon calcareous series which surrounds Mount Playfair and extends through Babbiloora, Boggarella, and Chesterton to Hebron, Silverleaf, Toolumbilla, Womblebank, and Injune Creek. The country here is absolutely like the Toolumbilla country—brigalow-belar-myall scrubs, some patches of open plain well grassed, and heavy black to chocolate soil.

Messrs. Cameron and Godfrey, boring contractors, have kindly given me information about bores on Boggarella and Babbiloora which enables one to say that Babbiloora is situated near the north-east edge of the calcareous Walloon belt, while Boggarella is closer to the south-west edge of the same belt. Mr. Cameron informed me that in No. 3 bore on Boggarella he bored through, between 600 and 700 ft., a very light black substance which had a glassy fracture, floated like a cork on water, and which could be cut or moulded like wax and was inflammable. There can be little doubt that this would be an oil residue, thus affording valuable subsidiary evidence of the oil possibilities of this zone. Oil shales occur in the Dividing Range between Nive Downs and Lake Salvator, in the Lower Walloon belt.

As already mentioned, the Bundamba sandstone underlies and outcrops north and east of the Lower Walloon. It extends on the surface, except where basalt-capped, from Carnarvon Station south nearly to Babbiloora and west to Lake Salvator, and from Lake Salvator north-west to parts of Castlevale.

It is doubtful whether the Ipswich formation exists in the region west of Lake Salvator. It it does, it has probably thinned out considerably or else the dips on Castlevale are very steep.

It has already been pointed out that Bowen Marine (Upper Marine) fossils occur halfway between Castlevale and Mantuan Downs. This locality then links up with Nardoo, Vandyke, Wealwandangie, &c., to the east and with the country between Alpha and the Dividing Range on the north.

What happens to the Ipswich and Bundamba formations north of Castlevale? This problem is not easy to elucidate, and the only evidence available is the meagre data afforded by bores for sub-artesian water. Desert Sandstone covers most of the Dividing Range north of Castlevale, according to the information culled from all sources. Perhaps there are other sandstones as well, but, even if there is, the bore sections between Jericho and Alpha suggest that for this stretch we have Upper Bowen coal measures below the superficial Desert Sandstone. In my opinion, the Ipswich-Bundamba and Lower Walloon were never deposited north of the Central Western Railway. These formations strike west from Castlevale underneath the Upper Walloon, the Warrego-Gowan Range forming the shore-line between the North Queensland area which was land in the Early Mesozoic, and the South Queensland basin which underwent continuous sedimentation from the Late Palæozoic to the end of the Lower Cretaceous. The Upper Walloons rest directly upon Permo-Carboniferous rocks in the Pentland district as shown by Mr. Reid, and at Mount Mulligan as shown by Mr. L. C. Ball. I found the same succession in the Cooktown hinterland.

III.—EVIDENCE OF THE BORES ON FOLDING, &c.

As much evidence as possible was collected in the shape of bore data, but it was found of little use in the Tambo district in determining structure. The sub-artesian bores around the Enniskillen Range draw their supply largely from the base of the Desert Sandstone, which has no bearing on folding, but considerable bearing on Upper Cretaceous geography. The bores which draw sub-artesian (usually very saline) supplies from the Marine Cretaceous are useless, since the sand and conglomerate bands in the Marine series are lenticular, and seem to have no definite relation to structure but occur in varying positions. The artesian bores in this district are also useless for comparison, since some situated on low ground as along the Barcoo—below 1,200 ft. above sea-level—may tap the first water supply, while in other bores situated from 1,300 to 1,450 ft. above sea-level

the pressure of the first water supply was insufficient to make it rise to the surface and the bores were continued to the second, third, and fourth supplies until the water rose to the surface and flowed. The depths from which the water is tapped are consequently not comparable. We find, therefore, that trying to work out the dip from the depth of different waters is futile except one can get a complete history of each bore, and even then only the deep bores penetrating to the Walloon water supplies are of any use.

In studying the artesian bore data we find that there is a belt immediately west of the edge of the basin striking north-north-west from Burenda through Nive Downs, Lansdowne, Tambo, Greendale, Mount Enniskillen, Northampton Downs, to Blackall where the artesian water is deep. The first supply of flowing water is generally not met with at less than 2,000 ft. In some cases it has been necessary to go more than 3,000 ft. for flowing water, but in each such case the reason is found to be that the elevation, as in the case of the Downfall bore on Lansdowne (elevation 1,445 ft.), was too high to allow the first Walloon supply to flow over the casing.

It is apparent that this belt constitutes a marked syncline in which the dip, usually so gentle, reaches 400 ft. in the mile or more to the south-west. That it is nearly monoclinal is shown by the fact that bores west of this belt get their first artesian supply from nearly the same depth. Thus the Minnie Downs, Ravensbourne, and Macfarlane bores, twenty to forty miles west of Tambo, draw their first artesian water from about 2,000 ft. Evidence from these bores then shows a great flattening of the dip, west of Tambo. However, only a few miles north-west of the Macfarlane bore there are mud springs, and there are two bores, one on each side of the Barcoo, drawing flowing supplies from a depth of 450 and 460 ft. respectively. These two bores lie on the western side of the deep zone. Such shallow artesian water and mud springs are indicative of the existence here of a buried ridge of old rocks bringing the artesian water near the surface, or of a dome in the newer formations. Probably a slight anticline moulded on this buried ridge exists along the Enniskillen Range, and anticlinal conditions certainly obtain further south on Oakwood Station on the Ward River, west of Augathella, for the Walloon supplies of flowing water are here met with at 1,300 to 1,700 ft. We see this: that the Cretaceous is not dipping west or south-west uniformily and constantly, if we can go on bore evidence, but the series is folded. If, however, we regard the Oakwood Station artesian waters as derived from the Cretaceous beds themselves, we are not in a position to draw any geological inferences from the depth from which artesian water is drawn. It is, however, my opinion that the artesian waters are mostly drawn from the Upper and Middle Walloon, and one can only conclude on that assumption that an anticlinal ridge exists from Moonbong in the Warrego Range through Oakwood to Charleville.

I am informed that 4 ft. of good coal was pierced at 60 ft., in a sub-bore on Bulburram holding. This would probably be Cretaceo-Tertiary. If it is Walloon, there must be a considerable dome at this point. In the Tambo station bore 37 ft. of coal (Walloon) was passed through at 1,700 ft.

In the Greendale bore, a few miles north-west of Tambo, a very strong scum or froth formed for many days on the water after the artesian water was struck at 3,200 ft. This scum or froth was probably indicative of the presence of some oil in the water first expelled.

IV.—OIL POSSIBILITIES IN THE TAMBO-BLACKALL AREA.

The conditions necessary for oil supplies are—

(1) Sufficient organic material to form oil;
(2) Porous strata or reservoir rocks in which the oil may accumulate;
(3) An impervious cover to prevent the escape of oil and gas;
(4) Suitable geological structures permitting the concentration of the oil and gas in commercial supplies.

(*See* L. J. Jones, Mining Resources, Bull. No. 31, N.S.W. Geol. Surv.)

To these may be added sufficient porosity in the beds rich in organic remains to allow the migration of oil to the reservoir beds, and also sufficiency of cover to give necessary pressure. The reported and alleged oil finds west of Tambo were in the Upper or Middle measures of the Cretaceous Marine. That traces of oil are present is indisputable. It is consequently necessary to see if the conditions are favourable for the occurrence of commercial supplies.

(1) Sufficiency of organic material. There is sufficient organic material in the Cretaceous Marine strata to form large quantities of oil. The organic matter is mostly of molluscan (shellfish) and seaweed origin. The oil traces on Macfarlane Downs are in beds which are also rich in pyrites (marcasite) and "copi" (gypsum). Everything points to the origin of the oil from molluscan remains, which are exceedingly abundant in the oil-containing beds.

(2) Porous strata. The Cretaceous Marine series is composed principally of impervious shales and equally impervious calcareous sandstones and mudstones. Some thin grit and gravel bands have been met with in the deeper bores, but these so far have been saltwater-bearing and have not yielded appreciable indications of oil. There is a paucity of reservoir rocks in the series.

(3) An impervious cover. The whole series of the Cretaceous Marine is fairly impervious, and the hard bands met with in drilling particularly so. The result is that the oil is confined to the beds which yielded it; there has been little scope for concentration and migration.

(4) Suitable geological structures. The analysis of bore data points strongly to the conclusion that there are folds in the Cretaceous Marine, and that the area on which oil-prospecting was carried on is the eastern flank of a considerable fold. It is therefore not favourably situated to get commercial supplies.

(5) The impervious nature of the strata generally is unfavourable for oil migration.

(6) As already shown, the thickness of rocks removed from the Cretaceous Marine in this area by denudation before the Desert Sandstone was deposited can have been only about 1,500 ft., a thickness insufficient to yield the high pressures necessary to induce the production and migration of oil. The Cretaceous Marine strata have never since their deposition been deeply buried under a mantle of sediments. The Desert Sandstones laid down after the Upper Cretaceous were never a thick series in these parts.

The Cretaceous Marine series consists largely of dark black, blue-grey, and brown fossiliferous shales with bands of mottled, low-grade kerosene shale. These have always been regarded as favourable for oil, yet when all factors are considered the Cretaceous Marine system is unfavourable in this region in—

(1) Lack of porous reservoir rocks;

(2) Too gentle folding to allow migration in so late a formation without sufficient cover to produce great pressures;

(3) Probably not truly anticlinal at Macfarlane Downs;

(4) Rocks too impervious to favour rapid migration;

(5) Insufficient cover to have yielded the necessary pressure.

The occurrence of mud springs on Enniskillen Downs north-west of Macfarlane Downs, and of shallow artesian flows, should have led to initial prospecting here, as there is more likely to be favourable geological structure there than at Macfarlane. Yet on the whole the balance of evidence is unfavourable to the prospects of oil in the Cretaceous Marine.

Nevertheless there is in the series a possibility of getting a "poor man's field" if prospecting and the study of bore records can definitely elucidate favourable domes and anticlines, and especially where there is evidence of great thicknesses of

Cretaceo-Tertiary rock overlying the Marine. One cannot in fairness condemn the Cretaceous Marine utterly as a possible oil region. But it is nevertheless true that oil prospects are rather more favourable in the Lower Walloon and Upper Bowen Series, which possess all the geological conditions favourable for the occurrence of oil.

In case of further prospecting in the Cretaceous Marine between Tambo and Blackall, I would advise trying on Enniskillen Station at the northern point of the Enniskillen Range about twelve miles north-north-west of Macfarlane Downs in the mud springs area, and on Bulburrum where the 4-ft. coal-seam was obtained.

V.—THE SUPPOSED OIL INDICATIONS IN THE TAMBO-BARCALDINE DISTRICT.

Mr. Hoddinotte, of Caldervale Station, has drilled a large number of sub-artesian bores in the Tambo district. In very many of these he drilled through kerosene shale, and obtained a float on the water bailed out which he supposed to be oil, especially as there was a very noticeable petrol smell accompanying the float. It was this which led to the prospecting at Macfarlane Downs, twenty miles west of Tambo. Driller Hannah, who has very extensive Queensland drilling experience, noticed the same kind of froth on Dunblane Station where he is drilling a sub-bore near Saltern Creek, the oil shale and broth occurring between 200 and 380 ft. in this locality. Driller Hannah informed me that it was very common in the Barcaldine district and also in the Kynuna district. He regards the froth as due to traces of oil, but says emphatically that in his opinion we will get no payable oil above the artesian water in our artesian area. The Saltern bore gave clay and shale to 200 ft., black oil shale from 200 to 380 ft., blue sandy clay 410 to 412 ft., gravel with pyrites 510 ft., sand-drift 520 to 530 ft., below which black shale, pug, to 620 ft. The occurrence of pyrites in certain beds seems frequent in the Cretaceous Marine. Gypsum is of more universal occurrence. The source of the sulphur in both minerals is no doubt the flesh of the entombed mollusca. The strong benzene-like smell accompanying the froth on the bailed water, in the bores which have been taken as indicating oil, suggests that light hydrocarbons only have been formed from the organic remains, since the heavy hydrocarbons have a different smell. The heavy hydrocarbons also retain sulphur. A process of partial oxidation has brought about the formation of light unsaturated hydrocarbon sulphate of lime and carbon dioxide and organic acids, the latter combining with sodium carbonate to form salts.

Altogether five shallow bores have been put down by Mr. Hoddinotte on the areas recently taken up west of Tambo—all bores situated close together about two miles south of Macfarlane

Station (*see* plan). One of these, the most easterly, was sunk to 1,200 ft. for artesian water, Mr. Millar doing most of the drilling of this hole. In this bore (E) the supposed oil indications were first got at 76 ft. and another zone yielding froth near the 1,100 to 1,200 ft. level.

The following data were obtained from Mr. Hoddinotte about each of these bores:—

—	Salt Water.	Oil Scum.
	Ft.	Ft.
Bore E	70	76
Bore F	100	95
Bore G (Brett's)	70	82
Bore J (400 ft. deep)	88	80
Bore H (new hole sunk in my presence)	65	65

In most cases the salt water was obtained before the oil scum. The scum consists of a very minute fraction of free oil liberated from oil shale by the pounding, which forms films round air globules introduced in the drilling and bailing, and the bubbles, together with bubbles enclosed by a natural soap, float up large amounts of comminuted oil shale.

The complete section of the bore put down in my presence was as follows:—

	Ft.	Ft.	
Yellow clay	0	14	
Decomposed shales wth copi ($CaSO_4$)	14	20	
Yellow and blue shale with copi	20	37	
Dark shales (solid)	37	44	
Dark shales with traces of fossil shells	44	48	
Black conchoidal shale wth fish scales		50	
Blue-black shale, no fossils	51	53	
Blue-black shale with fossil remains	53	57	Strong benzene smell commences at 53 ft.
Blue-black and grey shales alternating with no fossils	57	59	Faint smell of benzene
Grey and dark shale, no fossils	59	61	No benzene smell
Black shale rich in fossils	61	65	No marked smell
Shales heavily charged with salt water, cutting bit put on, no core	65	71	Strong benzene smell, floating scum
Black shale with mundic (iron pyrites)	71	72	do.
Blue-black shales	72	91	Strong benzene smell, heavy floating scum

The scum looks like soap bubbles or frog-spawn. The fossils are marine mollusca, both Ammonitidæ and Lamellibranchiata. Foraminifera also seem present.

The phenomenon which has led to the enthusiastic search for oil in this locality is practically the same which is used in mineral separation in floating up ores. It is highly deceiving to the person not acquainted with chemistry and metallurgy. Driller Hannah's conclusions, that oil is widely present in minute quantities in the artesian beds but probably nowhere in payable or workable amount, will probably turn out correct, although it is possible that isolated areas may yet be found where conditions may be more favourable for concentration.

Mr. Hoddinotte informed me that a very large scum kept forming for some time, and floated away on the Greendale bore when the artesian flow was first struck. This bore taps the Walloon Series, in which geological conditions for the preservation of oil were more favourable, but in the absence of any definite knowledge of or analysis of the scum there obtained no deductions can be drawn from it.

The samples taken at the Macfarlane oil bore put down in my presence were the skimmings of roughly 1,350 gallons of bailed water. The skimmings consisted mostly of gas and air bubbles with floated shale in an impalpable state. As the bubbles broke the scum subsided, and actually amounted to less than half a gallon of slurry.

Two samples of froth or scum were collected for analysis. The first, G.S. 53, represents the slurry collected between 65 ft. and 83 ft. during the progress of drilling; the second, G.S. 54, represents the froth on the bailing from 83 ft. to the bottom of the bore. The following is the report of the Government Analyst, which came to hand after the above report was written:—

> "There was no oil smell when the bottles were opened, and no light oil was obtained on distillation.
>
> "Extraction with ether gave slightly fluorescent solutions which contained only traces of oil.
>
> "On evaporation of the ether, traces of dark oil were noticed. The amount of oil so obtained was ·0007 per cent. of the weight of the sludge in No. 53 sample, and ·0004 per cent. in No. 54 sample.
>
> "The sludge was then filtered and the solid matter was subjected to destructive distillation. A very dark, sticky oil was obtained in the distillates, the amount being equivalent to 3·1 gallons of oil per ton of solids in No. 53 sample and 5·8 gallons in No. 54 sample."

The beds carrying salt water are lenticular, and have in general no relation to geological structure. The only way to determine if anticlines are present in country showing so few outcrops is to pick an area for investigation and sink shallow wells to the solid shale, and get a geologist to inspect the wells and take the dip of the rocks. This should certainly be done in any similar region before money is spent on oil-drilling. No geologist would venture to pronounce an opinion on small structures, local folds, or faulting, without such trial holes being sunk. The artesian bores taken as a whole indicate, as already mentioned, a general south-west tilt of all the strata from Blackall to Nive Downs, and an anticlinal rise further west between Ravensbourne and Charleville, but even this inference is scarcely on the plane of established fact.

Since the work on the Enniskillen bores was completed, several bores in the country north of Caldervale have yielded

traces of oil. This oil comes from the Walloon strata, which structurally and lithologically have a much better chance of yielding oil reservoirs than the Cretaceous beds. Oil prospecting is still in progress east of Tambo in the Middle Walloon belt of Old Malta Station.

VI.—FOSSILS.

Typical Walloon fossils of the genera Cladophlebis, Tæniopteris, Otozamites, Sphenopteris, Neocalamites, Equisetites, and Brachyphyllum have been collected by the writer between the Nive River and Caldervale, and thence to Old Malta and Playfair; and typical marine fossils in the Tambo district.

ACKNOWLEDGMENTS.

I am greatly indebted to Mr. Millar of Macfarlane Downs Station, and to Mr. Hoddinotte of Caldervale Station, for their unstinted assistance in the work, and for putting horses and cars at my disposal to get to those places which had to be visited.

PART F.

I.—GENERAL REVIEW.

We see from the foregoing that the various Mesozoic formations are, in the area so far examined, occupying definite belts in their right order, and not dabbed irregularly here and there as suggested by older maps. Closer examination has resolved the old Desert Sandstone areas shown round the margins of the artesian basin into a multitude of sandstones of various ages, from Permo-Carboniferous to Tertiary with interbedded shales.

The whole series of formations from Upper Carboniferous to Cretaceous lie practically conformably on one another on a north-south line from Emerald to Mitchell. A great unconformity occurs between the Cretaceous Marine and the Cretaceo-Tertiary.

Towards the east the sequence becomes interrupted as the Burnett Divide east of the Dawson Valley land in the Lower and Middle Carboniferous, and was submerged during the Upper Carboniferous (Lower Marine), again uplifted during the Permo-Carboniferous, and not affected by sedimentation again until the Clematis (Borallon) period. The thinning out of the Clematis and Ipswich formations and the abundance of conglomerate seams in them are strongly suggestive of numerous oscillations during Early Mesozoic times at this end. During the Bundamba (Late Triassic) and Walloon Jurassic, sedimentation proceeded steadily. Towards the Early Cretaceous a great uplift took place which built up very high land, which might have been the source of Late Cretaceous (Cretaceo-Tertiary) glaciation.

Towards the west near Castlevale there are some links yet unsolved. It appears probable, on information received and coal and bore data scanned, that the Ipswich and Bundamba as well as the Lower Walloons take on a steep tilt, and bend to the west or south-west in strike under the Cretaceous. The dips of the Walloons even at Caldervale and Malta are higher than experienced in the Roma-Mitchell area. Unfortunately, the wide expanse of Cretaceo-Tertiary shown on existing geological survey maps between Tambo and Alpha, and certainly confirmed by the writer in the Pine Hill to Alpha region, obscures the trend of the underlying rocks. Detail investigation near Castle Vale in the rough gorges where I have not yet been can alone definitely solve what takes place in this region.

It appears quite certain that in most of Central and North Queensland, and in West-South Queensland, west of the Grey Range, the sequence is—

Cretaceo-Tertiary (Big Unconformity),
Cretaceous Marine (Rolling Downs),
Upper Walloon (Big Unconformity),
Upper Permo-Carboniferous in parts, and in other parts the Cretaceous overlaps the older Palæozoic as in the Barkly Tablelands.

The character of the rocks observed is very consistent in each formation from wide areas—

(*a*) The Cretaceo-Tertiary rocks universally consist of mudstones with little bedding, and coarsely jointed and cracked, and containing in places tertiary leaves and freshwater mussel remains, and muddy sandstones similarly badly bedded and coarsely jointed, and containing numerous conglomerate beds.

The sandstones on weathered faces show variegated colours, white, red and yellow, little caverns eroded out and encrusted with oxide of iron stain.

Deposition seems to have taken place under semi-arid conditions. The soils are often red very sandy soils with spinifex, and can only be confused with certain limited belts of red sandstone in the Upper Walloon, some silicious red beds in the Ipswich and some in the Middle Permo-Carboniferous, but of these only the Upper Walloon red sands have at times the "Desert" flora.

(*b*) The Cretaceous is a calcareous mudstone series throughout, generally described by drillers as blue and black shale. A few sand-drifts of a lenticular nature may be met with in drilling, but they are purely a minor feature, and the soils and vegetation on the Rolling Downs are quite uniform and characteristic.

(*c*) The Upper Walloon contains some red sandstone beds in the area north of Mitchell and Roma. These were also seen west of Caldervale and north of Miles. Sometimes they have a "Desert" flora. The sandstones, however, are bedded and have a uniform red colour instead of the mottled colours of the Desert Sandstone. They no doubt indicate aridity at time of deposition. We have such red sandstones commonly interbedded in the Walloon rocks of the Gregory Range and Woolgar Range.

(*d*) The Middle Walloon is characterised for its whole length from ten to fifteen miles north of Miles west through Mooga, Orallo, Forest Vale, Redford, and Caldervale by a horizon containing a vast abundance of petrified wood silicified and in part opalised.

Any red soils in this belt are not due to contemporaneous aridity, but are of fair quality and owe their redness to weathering of ferruginous shales.

(*e*) The Lower Walloon Series is noted for its calcareous sandstones and shales, weathering into yellow clays, and black soils, the brigalow-belar flora, the salinity of the well and bore waters, and an abundance of coal-seams.

The Basal Walloon is a felspathetic sandstone weathering yellow and containing lenses of conglomerate. As we go west-north-west towards Tambo the Walloon Series gets more conglomeratic in all the members and contains more mica as a rock constituent, taking on some of the characters of the Ipswich rocks as we see them north of Roma and of Taroom, a fact which points to an unconformity and granite outcrops in the period of Walloon sedimentation somewhere in the region north-east of Tambo. We know some such outcrops occur in the Drummond Range, and others are probably buried under Desert Sandstone.

(*g*) The Bundamba sandstones are very silicious, but contain in their middle part a shale horizon which has been met with in the region of Crystalbrook (Maranoa River), south of Baffle Creek, north of Injune, and about four miles south of Gwambagwine, north of Taroom. This shale horizon contains intercalated ferruginous sandstone beds. Near the base of the Bundamba beds there are several beds of aluminous shale up to 20 ft. or more in thickness intercalated with coarse sandstone.

(*h*) The Ipswich beds are somewhat tuffy at the top, and contain a greenish tuffy sandstone giving red soil, and containing some intercalated red beds with Thinnfeldia immediately under the alternating white shales and conglomerates which form the top of the Ipswich. These tuffy beds occur well developed on Bullaroo Creek (Carnarvon Range) and at Dawson Vale and Cockatoo (Taroom district), and are very similar lithologically to some of the Esk beds. Red shales occur in the same localities in the series and also at the head of Buckland Creek, at Coorada, and at Auburn Station. They are quite a feature and yield a gravelly soil.

Oolitic ironstone occurs in the series developed to a great extent on Spring Station, Dawson Vale, and Cockatoo Stations in the Taroom district. These oolites appear from their association with greenish tuffy sandstone to be derived from iron out of the tuffy sediments (ferruginous tuffs). The Ipswich sandstones below the tuffy series are fine-grained, felspathic, and micaceous.

Some of the aluminous shales and sandstones in the Ipswich weather into mottled clay-banks with red, yellow, and white dabs not unlike what we see sometimes in the Desert Sandstone. Such banks are as numerous in the coastal region near Brisbane and Esk as at Coorada and Ghinghinda in the Taroom district and further west in the Carnarvon Ranges.

(*i*) The Clematis series we correlate with the Borallon (Lower Ipswich or Permo-Trias) of the Esk district. The sandstones are coarse, silicious and contain some mica, and in the Taroom area become very brecciated and tuffy at the base. They overlie a great series of dacitic and rhyolitic volcanics along the Dawson River.

In the Carnarvon Range the existence of contemporaneous volcanicity in the Clematis period is indicated by a thick body of manganiferous tuffy sandstone, overlying sandstones with tuffy red shales intercalated at the base of the formation (cf. Narrabeen Shales).

Throughout the Mesozoic, omitting the Walloons, we pass through great thicknesses of the same kind of beds. In the Walloon there are rapid alternations between shale, sandstone, and mudstone, but conglomerates are rare and true limestones absent. In the Upper Permo-Carboniferous we get frequent rapid alternations of different kinds of strata, including conglomerate and shell limestone. Blue, green, and varicoloured sandstones come in. These points enable one to discriminate in drill records between the Permo-Carboniferous and overlying formations.

Red sandstones similar to those in the Upper Walloon are common in the upper part of the Middle Bowen, overlying the Consuelo coal measures. (Greta age.) The sandstones below the Consuelo measures are highly conglomeratic, becoming coarse boulder beds with contemporaneous volcanics and interbedded varve shales in the Lower Bowen.

One of the most remarkable things in the geology of Eastern Australia is the wide extent and uniform character of Walloon and Bundamba sedimentation. It is the same class of beds we have under the Marine Cretaceous everywhere from Croydon (Gregory Range) and the Newcastle Range in North Queensland, or even in the Cooktown district, through the Dividing Range east of Tambo and north of Roma, and through the Darling Downs south to the Pilliga Scrub of New South Wales. The Upper Walloon beds pass conformably into Cretaceous Marine.

II.—BORES IN BLACKALL AND THE GOWAN RANGE.

The Blackall woolscour bore passes into rocks of a Walloon type at 1,349 ft. and finishes in sandy clay at 2,507 ft. The second and main water supply was got at 2,084 ft. There can be little doubt that Blackall and Tambo are situated approximately on the same horizon, and draw their main supplies of artesian water from the same horizon. At Barcaldine the artesian water is closer to the surface, hence it is reasonable to conclude that the Walloon rocks (Upper Walloon) get closer

to the surface here. This is also confirmed by the occurrence, as previously mentioned, of Walloon coal at a depth of 700 ft. in the Coreena bore, eighteen miles north-north-east of Barcaldine.

The Enniskillen Range, as already shown, is a residual of Cretaceo-Tertiary. I have not been further west in this latitude, but the Geological Map of Queensland 1899 shows the Gowan Range to be a westerly extension of the same formation. The Gowan Range itself terminates at Mount Grey where it joins a range running south-south-west into the Grey Range, and this divide (which separates the watersheds of the Bulloo and Barcoo) is also Cretaceo-Tertiary (Desert Sandstone).

It is of interest to point out that the line of the Gowan Range and Grey Range is practically the northern and western boundary of the synclinorium in which all the Mesozoic strata are represented.

As already mentioned in Part C, the Thornleigh bore passes into the Walloons at 3,100 ft., the Blackall bore at 1,400 ft., the Malvern Hill bore at 1,300 ft., while the Eromango bores pass into strata of an Upper Bowen lithological character.

It will be interesting now to extend these notes to show, on present available bore data, further reasons for the conclusions arrived at.

In addition to the Roma wet gas and dry gas from numerous bores in the Lower Walloon belt from Injune to Dalby, some of the bores which have yielded oil indications are—

(1) The Springleigh bore, completed to about 7,009 ft., struck shale carrying kerosene at 5,437 ft., and dark paraffin wax at 5,450 ft., and brown rock carrying oil from 5,779 to 5,839 ft. These formations appear, on the lithological character of the overlying beds (including shell drift, 4,823 to 4,873 ft.), to belong to the Permo-Carboniferous. The Upper Jurassic are represented between 3,820 and 4,553 ft. Springleigh is situated on the Yaraka railway north of the Gowan Range.

(2) Ruthven bore (Lat. 24° 7′, long. 144° 4′), depth 4,105 ft. The water supply of 340,000 gallons per diem was got at 4,070 ft. and was very hot. Paraffin wax was got in this bore and natural gas also issued from it. The Cretaceous beds reach to 2,587 ft. and the beds underlying are probably Walloon, though they may be Permo-Carboniferous. This bore is near Isisford and north of the Gowan Range (north-west of Mount Grey).

(3) Bimerah bore (Lat. 24° 8′, long. 143° 35′), depth 4,310 ft.; artesian supply 6,300 gallons from 3,925 ft. In this bore a small quantity of petroleum was struck at 3,640 ft. and small bands of coal at 3,700 ft. The nature of the beds pierced indicates Cretaceous to 3,250 ft. and then Walloon to the bottom. This bore is also north-west from Mount Grey but west of the Ruthven bore.

(4) Thomson watershed bore (Lat. 23° 58′, long. 144° 6′), nearly north of the Ruthven bore, depth 3,319 ft., yielding 13,800 gallons of water from 3,207 ft., temperature 155 deg. From this bore a considerable quantity of gas escaped and yellow drops of petroleum wax were seen floating on the water (Aug. 1899).

(5) Eromanga bore (Lat. 26° 54′, long. 143° 18′), well to the west of the Grey Range, yielded inflammable gas burning with a blue flame; water saline and gaseous.

(6) Westland bore—(*a*) Lat. 23° 48′, long. 143° 47′; (*b*) Lat. 24° 2′, long. 143° 57′. These two bores are about north of Bimerah, and in (*a*) there were for eighteen months from the beginning (1898) great pulsations in the evolution of firedamp, and (*b*) in 1899 yielded 40 cub. ft. of inflammable gas per hour.

(7) Tara bore (Lat. 23° 36′, long. 145° 3′). Considerable quantity of inflammable gas evolved. This bore is down to 3,500 ft. and draws on the Walloon strata.

These bores are authenticated records of the occurrence of gas, in some cases with petroleum residues. In that area of Queensland which lies west of the Grey Range and north of the Gowan Range the drillers tell of many other similar occurrences, which have unfortunately not been recorded in departmental files. The majority of such occurrences are fairly near the ranges mentioned.

(8) Alice Downs (Lat. 24° 13′, long. 145° 29′). Outbursts of gas with each water supply, probably from Walloon coal-seams.

Since petroleum residues are an indication of the pinching out of an oil basin this affords additional evidence of an unconformity along the ranges mentioned.

The Murweh and Claverton bores also yielded gas (*see* Queensland Mineral Index), but they lie in the synclinorium in which the Mesozoic sequence is complete, as is the case with Roma.

The following bores are interesting as having bottomed in formations undoubtedly older than Mesozoic:—

Locality.	Depth.	Age of Rocks.
	Ft.	
On Morven—Morven (Murweh)	2,657	Primary
Eddystone Vale—Bonus Downs (south end of Morven)	3,424	Slate (?)
Buried Ridge—Tatala	1,633	Mica schist or granite
On Hungerford—Boorara	Shallow	Granite
Outlier—Hungerford	(*See* Min. Index)	do.
On col joining the Cloncurry and Etheridge Massifs—Canobie	..	do.
Eulolo	Not deep	do.
Manfred Downs	(*See* Min. Index)	do.
Oxton Downs	..	do.
Barkly Tableland formations—Cambrian ?—Toolebuc	..	Granite
Warenda	Shallow	Massive limestone and quartzite
Rocklands (Moreston Downs)	do. ..	do.
Herbertvale (Barclay Downs)	do. ..	do.
Beaudesert (Cloncurry district)	do. ..	Granite and old rocks

To these might be added the Eromango and Middleton bores, which appear to bottom, like the Springleigh bore, in the Permo-Carboniferous.

Owing to the great thickness of Cretaceo-Tertiary and Cretaceous in the Longreach-Winton basin, few bores except those near the edge of the basin penetrate deeper than the Upper Walloon.

The main evidence of the great unconformity in this northern basin is therefore got by the actual sequence in the surface outcrops in the district north of Pentland and Hughenden, at Croydon, at the Woolgar field, and elsewhere, and a sequence in the bores near the edge of the basin corresponding with the surface sequence.

III.—PALÆOGEOGRAPHY.

On reference to the geological maps prepared with this report it is readily seen that the entire area south and south-west of the Dividing Range forms a huge trough. The area specially examined constitutes a vast monocline sloping southerly and south-westerly towards the centre of the syncline or synclinorium. The monocline is slightly corrugated with minor folds and terraces. The centre of this trough is near Surat, and it is strictly speaking three-lobed. The northern lobe extending from Surat to Blackall lies on a north-west axis, the eastern lobe is moulded on a curved axis which commences at Surat on an east-west direction and then swings south-east; this lobe extends nearly to the Brisbane and Logan Valleys at Rosewood and Boonah, and though broken by a recent anticline between Beaudesert and Boonah may be regarded as extending over the N.S.W. border into the Northern Rivers district of New South Wales as far as Grafton. The southern lobe extends south-south-west into New South Wales as far at least as Dubbo. The

western margin of the deep portion of the basin is the divide between the Nebine and the Warrego, though the basin may be regarded to extend to the Grey Range in Queensland and to the Cobar massif in New South Wales. The eastern margin of the basin is the Burnett Range, the Bunya Range, and the coastal ranges near Brisbane for the eastern lobe, and the New England uplift for the southern lobe. A gulf-like offshoot of the eastern lobe extends northwards towards Duaringa, and, by taking into due consideration the Permo-Carboniferous rocks as well as the Mesozoic, it appears that this three-lobed geosyncline has developed from a movement of depression commencing on a north-south axis nearly along a line extending from Bowen to Dubbo.

The terms "synclinorium" and "geosyncline" have been used above, and it is necessary to point out that this huge trough is not a geosyncline or synclinorium in the usual sense of the expressions as applied to the Alps and Himalayas, which have undergone prolonged sedimentation and then been uplifted, folded, crushed, and faulted so as to form immense ranges.

The coastal cordillera, as pointed out in my paper "Geological Unity of Eastern Australia" (Proc. Roy. Soc. of Q.), and "Some Geological Features of Northern Australia" (Proc. Roy. Soc. of Q. 1922) constitutes the principal synclinorium of the Australian Continent, the Australian Alpine chains. In the Late Cretaceous some of these ranges in Eastern South Queensland must have been between 10,000 and 15,000 ft. high.

The south-central synclinorium discussed above is quite different. It is a region which has escaped intense folding except in the eastern lobe (which is part of the East Australian geosyncline as well), and which is practically only a depression developed by loading of sediments and isostatic movement on a wide continental shelf.

The cordilleran or East Australian geosyncline commenced to subside in Early Palæozoic times; the re-elevation of it commenced and cessation of sedimentation practically ended with the Jurassic.

The south-central depression commenced in the Late Palæozoic and finished in the Tertiary, but lateral compression of sediments has been very slight, so that the sediments composing its rock fabric have almost the stratigraphical structure of epicontinental deposits.

Still further west, the area lying north of the Gowan Range and west of the Grey Range forms a still later depression, which commenced in the Early Cretaceous and ended in the Tertiary.

It is the two last-mentioned depressions which, through being in the main epicontinental, have most interest to the oil geologist.

It has been shown that sedimentation has been practically continuous in the south-central basin from Permian times to Cretaceous, and that there are sufficient structures showing the country north of Roma and further north in the Springsure-Rolleston district for one to locate minor structures suitable for oil-drilling. Nevertheless, the average dip over large areas is very low, as in the case of the American Midcontinental Oilfield, and especially in the Winton basin. This is illustrated by the following table of average dips computed from bore data:—

Northern Central.	Direction.	Slope or Dip of Strata on that Direction.
		Ft. per Mile.
Leilaville to Julia Creek	E.	20
Redcliffe to Horseshoe Bend, Hughenden	S.W.	10
Lammermoor to Bogunda	S.W.	14
Kynuna to Dagworth	E.	27
Tooleybuc to Middleton	E. by S.	7
Kynuna to Winton	S.E.	16
Dagworth to Winton	S.E.	12
Darr Downs to Winton	N.W.	11
Longreach to Winton	N.W.	7
Caledonia to Bowen Downs	S.	12
Bowen Downs to Darr Downs	S.W.	21
Hughenden to Winton	S.W.	23
Barcaldine to Longreach	W.	20
Central Longreach to Bimerah	S.W.	24
Ruthven to Bimerah	N.W.	30
Gowan to Thornleigh	N.	50
Tambo to Lorne	W.	40
Blackall to Alice Downs	N.	10
Blackall to Thornleigh	N.W.	34

The above all refer to the Winton depression.

Some typical average dips in the south-central basin (Surat depression) have already been given in the section comparing that basin with the Midcontinental Field

The eastern loop of the great basin of Permian and Mesozoic sedimentation is, as already shown, partly in the East Australian (cordilleran) geosyncline. The Mesozoic strata are frequently steeply tilted. I have shown elsewhere that the Bundamba beds dip steeply at angles up to 48 deg. along the east flank of the D'Aguilar Range north of Mount Mee. Messrs. Reid and Morton have demonstrated that the Mesozoic beds are very steeply tilted on the western flank of the D'Aguilar Range.

A great and very recent north-south anticline involving the Walloon and the Bundamba formations forms a mountain range between Beaudesert and Boonah. Dips are very steep on the eastern flank.

In Part D of this paper it is shown that a great synclinal in the Mesozoics exists along the line joining Miles and Taroom. East of this we find an unconformity or a series of uncon-

formities, so that one may say the valley of the Dawson and the Great Dividing Range west of Juandah, the Bunya Mountains, and a line joining Dalby and Warwick would approximately delineate the area in which the sequence of deposition of Permian and Mesozoic sediments is continuous and conformable as in the Carnarvons, from an area of discontinuous sedimentation involving unconformities and disconformities like those recorded by Reid and Moreton in the Esk district.

IV.—BURIED RANGES AND REFLECTED ANTICLINES.

In spite of the regular and conformable deposition of all the strata ranging from Cretaceous to Upper Carboniferous along the north-south line from Roma to Emerald, we have, as already shown, numerous buried ranges of old rocks representing Mesozoic island festoons. The Anakie massif and Drummond Range form a very marked peninsula in the Mesozoic seas. It probably extended southerly to Black Alley Peak (near Rewan), and the Permo-Carboniferous sediments were strongly folded over it, and much more steeply on its eastern flank than on the western. The eastern side of the fold was, moreover, faulted with the western area, forming the downthrow side, and the persistence of this fault south as far as the Charleville line near Amby, and the occurrence of granite débris in the volcanic ejacamenta near Kilmorey, suggest that this buried ridge might extend much further south than superficial evidence shows.

A branch of this major buried ridge extends under the Hoganthulla Range, showing at the surface near Eddystone Vale and at a depth of 2,000 ft. in the Morven bores, and further south in all the bores along the divide between the Nebine and the Warrego as far as the N.S.W. border. The Grey Range and Gowan Ranges overlie buried ranges of old formation, in part at least.

It has been shown that the Mesozoic sediments overlying these buried ranges are anticlinal in structure; they are in fact what Sydney Powers, in "Economic Geology for June-July 1922," calls "Reflected buried hills." These are of great importance in oil geology.

It has been shown also in Part C that the Desert Sandstone ranges appear to lie chiefly in valleys eroded about anticlines affecting the Cretaceous and low sediments. Further investigation of this question is very necessary to oil geology.

In the course of this work much fossil collecting has been done, and the net result of labours in that direction is that we are now in a position to harmonise our Upper Palæozoic and Mesozoic formations, and particularly our coal measures, with those of New South Wales.

V.—VOLCANICITY.

As a result of the complete investigation it is now apparent that the volcanic rocks represented in the great south-central "synclinorium" belong to three periods—

(1) Lower Bowen (Upper Carboniferous) volcanics, consisting of andesite, basalt, and rhyolite, as along the Nogoa, in the Springsure area, and east of the Dawson (*vide* B. Dunstan, Geology of the Dawson Mackenzie).

(2) Permo-Trias, overlying and intruding the Permo-Carboniferous rocks and underlying the Clematis (Borallon) series (Lower Triassic). Tuffy sandstones indicate a continuation of spasmodic volcanicity during the Ipswich (Middle Trias). The volcanics of this period were chiefly dacites and rhyolites.

(3) Tertiary (post Desert Sandstone) lavas, consisting mainly of basalt-flooded parts of the Carnarvon Range, Darling Downs, and parts of the Springsure district.

Trachytes belonging to this period occur in the Carnarvon Range (Gee Gee Gap) and on the divide between Broadmere and Glenhaughton. These three periods of volcanicity coincide with periods of strong earth movements—uplifts in the case of the Tertiary lavas, depression in the other two cases.

It is interesting to note that dacitic magmas were erupted in this state, principally in three periods—

(1) The Upper Devonian—Dacites represented largely in the volcanics of the Burdekin area, Mount Coolon, Kangaroo Hills, &c. Possibly some of these may belong to the second period, but most will be contemporary with the Snowy River porphyries (N.S.W.).

(2) The Clematis-Borallon period as represented on the Dawson Valley and along the Brisbane Valley.

(3) Tertiary, as in the Glass House Mountains.

In the Early Carboniferous there were andesites, basalts, and porphyries erupted coeval with elevation throughout Eastern Queensland.

The trachydolerites of the Middle and Upper Bowen period in the Bowen Coalfield were contemporaneous with subsidence.

VI.—MOUNTAIN RANGES AND STRUCTURE.

The correspondence between the direction of mountain ranges and line of strike is particularly noticeable in the case of the Great Dividing Range.

The spurs, like the Hoganthulla Range, the Sericold Range, &c., are usually also oriented in regard to structure, often corresponding with minor folds or anticlines. In some cases, like that of the minor anticline along Vandyke Creek, the creek valley corresponds with minor anticlines.

The Expedition Range lies in a great supplementary syncline east of the Anakie-Sericold anticline. Another minor anticline occurs north of Reedy Creek Station, and in it lies Bauhinia Station, but east of this we have the Dawson Valley syncline.

East of the Dawson Valley we have a highly metamorphosed area against which the sedimentary rocks of the south-central basin abut, and cut out with strong unconformity before and after the Lower Marine and minor disconformities during the Mesozoic. The Mesozoic rocks once covered the southern part of this old mass, forming a great anticline on the Burnett Range. The erosion of this caused the Mesozoic formations to sweep to the south-south-east in the region east of the Dawson at Taroom.

The Auburn uplift took place in three main stages—(1) A carboniferous uplift followed by erosion and deposition of the Lower Marine limestone: (2) a Permo-Carboniferous uplift which tilted the Lower Marine at angles of 30 deg., followed by erosion and later by subsidence and volcanic activity inaugurating Mesozoic sedimentation; (3) a Cretaceous uplift which raised the Burnett divide to a height of 10,000 to 15,000 ft., and which may have been responsible for the floating ice depositing the boulder mounds referred to.

Laterites.—Very interesting is the enormous development of laterite by decomposition of granite *in situ* on and east of the Burnett divide. This was first noticed by Mr. Morton and has been confirmed by Mr. Dunlop and myself.

An enormous granite area has been proved on the head waters of the Auburn, which were previously considered to run through Gympie formation.

VII.—OIL GEOLOGY.

It has been shown in this paper that Queensland possesses rocks of the right lithological nature and folded in the right manner to yield oilfields of great magnitude.

In conclusion it may be stated, that both recent developments in the study of oilfields and all recent work done on the Injune area combine to render it clearer and clearer that the

Injune series should become a commercial producer of oil, and that the chances of finding oil-pools in Queensland are far from gloomy.

What has been written leads to the interesting possibility of considerable oil developments along an extensive belt about 400 miles in length extending from the neighbourhood of Warwick north-north-west to Dalby and Juandah and Orallo along the Dividing Range, thence through Forest Vale and Hoganthulla, Killarney, and Boggarella to Caldervale, thence north-north-west to Malta. It is probable that the Lower Walloon belt then disappears to the west under Cretaceous sediments.

In Central and North Queensland, however, the Permo-Carboniferous possible oil-basin swings round the artesian area, forming a rim which in many places is hidden under later sediments, but it appears notably between Mantuan Downs and Alpha on the western side of the Anakie massif, and again north of Hughenden and Pentland. Further north we have it in the Taylor Conglomerate Range near the Mitchell River.

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(B. DUNSTAN, F.G.S., CHIEF GOVERNMENT GEOLOGIST.)

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The Queensland Upper Palæozoic Succession

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Prefatory Note.

Several years of extensive, systematic field investigations and careful study of the stratigraphical problems associated with our Upper Palæozoic Formations preceded this paper by Mr. Reid, who was thereby eminently fitted to undertake a work of such magnitude and importance in its probable bearing on Queensland stratigraphy.

Priority in these fruitful labours must be given to his elucidation of the structural features and the delineation, based mainly on extensive reconnaissance mapping, of the three divisions of the Bowen (Permo-Carboniferous) Formations within the Great Syncline.

The discoveries by Mr. Reid of *Lepidodendron australe* and *Spirifer disjunctus* at Mount Wyatt, one of the Star type areas, and of *Calceola* in a collection from Jack's "Gympie" beds at Ukalunda, opened a wide field for investigation and led to a comprehensive review of all the evidence on which the ages of these formations were previously assigned.

Subsequent investigations of several other Upper Palæozoic areas led him to believe that the sequence adopted in the State Geological Map (in MS. form) prepared in 1928, which placed the Drummond Series above Star and Rockhampton in the Carboniferous Period, was not in accord with facts as then revealed, and the following alternative was proposed:—

Permo-Carboniferous	Upper Bowen Middle Bowen Lower Bowen
Upper (?) Carboniferous ..	Gympie
Lower Carboniferous	Rockhampton
Lower Carboniferous to Upper Devonian	Star (= Drummond)

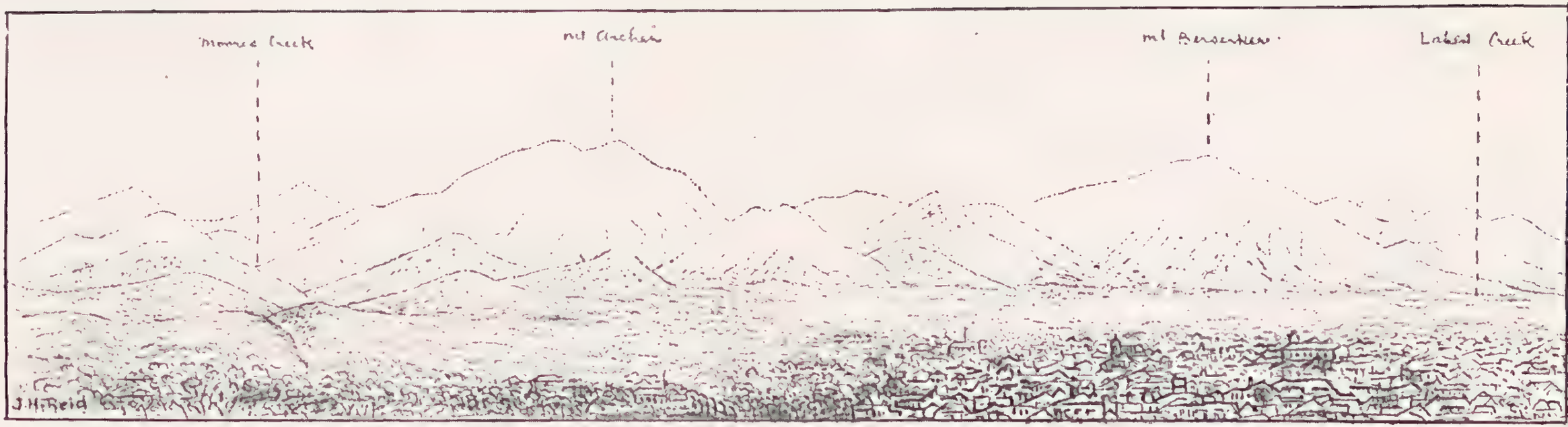
This paper sets out the evidence for the proposed classification in clear and concise form, and offers a most helpful and replete summary of stratigraphical and palæontological data, gleaned from the vast amount of literature on all formations ranging in age from the later Devonian rocks to the end of the Palæozoic era.

The evidence for a transition series (Gympie above) between Lower Carboniferous and Permo-Carboniferous is based mainly on the stratigraphical and faunal data of the Stanwell, Lake's Creek, and Gympie Goldfield areas and their field relationships to the Rockhampton and Bowen Series, particularly evidence as to a commingling of Lower Carboniferous and Permo-Carboniferous faunas in South-east Queensland and New England (N.S.W.).

The evidence on major folding movements for the period under review is discussed, and, while no conclusion could be reached with regard to orogeny about the Lower Devonian, a strong case is presented for definite orogeny in restricted regions about the Middle Carboniferous (Drummond Movement) and in late-Permian time.

It is but natural that a work of this nature, through the introduction of new ideas or the criticism of those previously entrenched, should meet with opposition, but herein lies the shortest path to progress and the ultimate discovery of the truth.

B. DUNSTAN,
Chief Government Geologist.



BERSERKER RANGE AND ROCKHAMPTON FROM ATHELSTANE RANGE LOOKING EAST OVER THE DEVONO-CARBONIFEROUS SYNCLINE.

The Queensland Upper Palæozoic Succession.

I.—INTRODUCTION.

This paper might be considered a review of the available geological literature pertaining to the later divisions of the Palæozoic Era in Queensland. It is, admittedly, an attempt to piece together an all too imperfect and disjointed geological record which must of necessity exist in such an enormous area as Queensland until very much more geological survey work is accomplished. There are at present several conflicting interpretations of both stratigraphical and palæontological data that need further consideration and discussion in the light of results obtained in the last few years; none at the moment are perhaps more important than the status of the Gympie Formation and the question of whether a transition fauna between the Lower Carboniferous and Permo-Carboniferous existed in Queensland.

When Dr. Jack in 1892 issued the first State Geological Map of Queensland, considerable uncertainty was still apparent in the stratigraphical succession within the Upper Palæozoic. Thus, as one example, the Star Formation, firstly considered Devonian along with the Gympie, was afterwards relegated to the Permo-Carboniferous and placed *above* the latter while, continuing upwards, appeared the Lower, Middle, and Upper Bowen respectively in the same Permo-Carboniferous system. Gympie thus followed the Middle Devonian in the established succession, and the term Carboniferous did not appear. This order still appeared on the Geological Sketch Map of the State prepared under the supervision of Mr. B. Dunstan in 1905. In the State Geological Map (in *MS.* form) prepared in 1928 by the writer, under the direction of the Chief Government Geologist and in collaboration with colleagues of the Geological Survey, the following classification was adopted by the Survey for the period under review:—

Permo-Carboniferous	Upper Bowen Middle Bowen Lower Bowen
Carboniferous	Drummond Series (? = Star) Star and Rockhampton Series

This classification thus showed considerable emergence from the confusion that existed formerly. The most important change was the dropping of the Gympie Formation of Jack as being equivalent to the Lower Bowen, and the recognition of purely Carboniferous formations.

As the result of work carried out during 1928 in three extremely important areas in their bearing on the geological succession, the writer was not afterwards of opinion that the above order represented the correct sequence for Queensland, and consequently proposed another for discussion as follows:—

Permo-Carboniferous	..	Upper Bowen Middle Bowen Lower Bowen
Upper (?) Carboniferous	..	Gympie
Lower Carboniferous	..	Rockhampton
Lower Carboniferous and Upper Devonian		Star Series (= Drummond Series)

The latter classification proposes some rather radical changes in the succession as compared to the preceding one, as follows:—

(1) The Star Formation, as defined by Jack, is not considered to be the equivalent of the Rockhampton Series, and is probably contemporaneous with it only in its upper division as a freshwater representative, while the lower division, in one type area at least, is definitely of Upper Devonian age, and it is suggested that all known marine beds of the Star Formation are probably of that age, and may range down to the Middle Devonian.

(2) The Drummond Series, far from being the next series of sediments below the Lower Bowen, is considered to be the equivalent of the Star and, therefore, though the term is much used, there would seem to be no imperious need that it should appear on the State Geological Record, the Star having priority as the type. As regards this correlation, the writer is in agreement with Jack and Etheridge.

(3) The Gympie Formation of Jack[1] was an indefinite term for an immense development of strata in the south-eastern portion of the State, to which neither a base nor a top was recognised. It included the Lower Carboniferous Series of Rockhampton, since separated, as well as the auriferous formation (type area) of the Gympie Goldfield. It is suggested in this paper that the term be retained for a formation that is considered transitional between the Lower Carboniferous and the Permo-Carboniferous, and in which the Gympie auriferous series apparently represents a closing stage. This paper necessarily does not concur with the extensive correlations attributed to the Gympie Formation in the past, and which have been the subject of adverse comment by several geologists. In regard to the Gympie (transitional) Formation, it is proposed herein to divide it into an upper and lower series as follows:—

GYMPIE*	.. .. ..	Monkland Series Neerkol Series

Monkland is a mining centre at Gympie, the slates of which have been the chief enclosing rock of the auriferous reefs on that field. It

* The Chief Government Geologist concurs with this suggested division.

typifies the higher division of these rocks in which there is a strong Permo-Carboniferous faunal assemblage. Neerkol Series is suggested in replacement of the "Stanwell Marine Series" of Reid and Morton, and is that in which, on the existing records, the first elements of the Permo-Carboniferous fauna appear to a restricted degree. Neerkol is a locality near Stanwell where this series is exclusively developed.

It is for the purpose of discussing the strength or otherwise of the above sequence, which represent the interpretations of the writer, that the present paper has been prepared. The question thus is—What is the true succession from the later stages of the Devonian to the end of the Palæozoic era?

It is little wonder that uncertainty reigned among the pioneer geologists of Queensland when the first State classification was formulated, for the field was enormous and the workers few. Further, economic mining work predominated over stratigraphical investigation, and progress was relatively slow in the determination of stratigraphical sequence and relationship. Tremendous assumptions had to be made to present a map in consonance with the knowledge of that time. As late as 1916 Andrews[2] showed that our knowledge of some of the Permo-Carboniferous rocks, "such as the Gympie of the Queensland geologists," was far from satisfactory, while in 1920 Jensen[3] asserted that the Gympie Series had been made "a geological scrap-heap." The grounds for such reproach are very much lessened to-day, for research into the Permo-Carboniferous coal measures has immensely increased the sum of our knowledge, and this has been rendered more fruitful by the accompanying palæontological examinations of Dun and Whitehouse. Opportunity will be taken to revise some of the conclusions of the writer in his advance reports on the Isaacs River Coal Basin, for a much clearer and vaster perspective of the various problems has come from subsequent work, both in the Great Syncline of Queensland, as for instance in the Clermont and Emerald-Springsure regions, and in outside areas, such as the Monto-Mulgeldie district of the Upper Burnett and the Rockhampton-Stanwell district. In the light of knowledge acquired in this work, he will also offer constructive criticism of the work and conclusions of several other workers in this period of Queensland geological history.

For the coastal half of Queensland, in the Central and Southern portions of the State, the view is especially put forward that from the later Devonian rocks there was a succession of sedimentation (largely marine) through the Carboniferous up to the late Permian which would normally be interspersed with breaks (non-sequences) due to subordinate crustal reflexes within the geo-syncline. Throughout the Carboniferous there was dominant mud deposition in which occasional but often important reef-formed limestones (oolitic), consisting largely of crinoids and corals, were deposited and formed the most extreme

variation in type in the lower division, while throughout there were spasmodic and important periods of vulcanism. Apparently towards the end of the Carboniferous there was a noticeable lifting of the sea-bed, introducing sedimentary non-sequences marked by the subsequent development of widely distributed boulder-conglomerates (Stanwell, Tooloombah, Silverwood, &c.). These alternated with dark marine muds of the Carboniferous type or with *Glossopteris*-bearing shales. This period might be expressed as the "passing-over" stage from "Carboniferous" to "Permian" conditions of sedimentation, and this change can scarcely be primarily disconnected from the crustal movement that evidently produced widespread paralic deposits in the geo-syncline after a long period of marine sedimentation. This change was followed by renewed vulcanism in certain areas, and by a more westerly transgression of the sea than during the Carboniferous period, for then a strongly contrasted type of marine sediments ("Permian") more or less uniformly appeared and evidently spread largely over the geo-syncline, for remains of this later sedimentary type have been found to extend, disconnectedly, from west of Springsure to near the coast in the Styx district.

Reverting to the mention of geological work accomplished in 1928 in three extremely important areas, these comprised—

(1) Mount Wyatt, which Jack included with the Star River, Keelbottom, and Harvest Home as the type areas of the Star Formation ;

(2) Drummond Range Section and several traverses across its northerly continuation in the region lying to the east of the Belyando River ;

(3) Rockhampton-Stanwell area almost completely traversed from the Berserkers to Westwood.

In the last two areas, the work to a major extent was carried out conjointly with the writer's colleague, Mr. C. C. Morton, of the Queensland Geological Survey, to whom at least equal credit must accrue for any merit that might be attached to the results achieved.

In New South Wales great additions have been made in recent years to the store of knowledge regarding the sequence and relationships of the late-Palæozoic period, and mention will be made under the next heading of the work drawn on for information regarding that State.

Besides attempting to define that which it appears, in the present state of our knowledge, may be the correct succession in Queensland, an attempt will be made on the co-ordination of the greatly increased knowledge in Queensland and North-eastern New South Wales, both as regards succession and tectonics, for it is fairly evident that the coastal region between Newcastle (N.S.W.) and Bowen (Queensland) has claims to be considered as a geological unit during late-Palæozoic time, in many respects having common conditions of sedimentation, of intrusive and extrusive phenomena, and perhaps more or less responsive to identical crustal deformations, as well as to allied epeirogenic movements.

II.—ACKNOWLEDGMENT DUE TO RELATED LITERATURE.

The literature pertaining to the period in Queensland and New South Wales, of both general and local character is very extensive, and mention can only be made here of those reports found most relevant in a general sense to the purpose of this paper, or of critical importance in any aspect. To somewhat mitigate this omission here, a list of literature cited will be found at the end of the paper. Tribute must be paid to the geological pioneers of Queensland, without whose foundation work this publication could not have been attempted.

In Queensland, Jack and Etheridge's "Geology and Palæontology of Queensland" obviates almost entirely the necessity of going further back than the year 1892, so comprehensively does it condense all the earlier reports of the pioneers bearing on the questions involved, and so rich is it in citations of the more important information. Bryan's "Glossary of Queensland Stratigraphy" gives, succinctly, information as to the origin and vicissitudes of such terms as the Star, Gympie, Rockhampton, and Permo-Carboniferous. Among Geological Survey publications and various reports most used are Dunstan's Dawson-Mackenzie River Coalfield report and the Queensland Mineral Index, Ball's Iron Ore and Silverspur District reports, Jensen's reports on the Permo-Carboniferous, Reid and Morton's Central Queensland Section, and Whitehouse's palæontological notes; also the writer's contributions to the literature of the Permo-Carboniferous Coal Measures. Richards and Bryan have contributed, jointly, "Permo-Carboniferous Volcanic Activity in Southern Queensland" and the "Geology of the Silverwood-Lucky Valley Area," both extremely important on account of the Permo-Carboniferous rocks developed there and their geographical position near the southern border of Queensland. Bryan's reports to the Carboniferous and Permo-Carboniferous Correlation Committee at the Perth and Hobart meetings of the Australian Association for the Advancement of Science have also been referred to.

In New South Wales fertile sources of information are found in David's retinue of papers embracing the Geological History of Australia, the Vegetable Creek and Hunter River Memoirs, Chief Tectonic Lines of Australia, and, with Sussmilch as co-author, The Sequence, Glaciation, and Correlation of the Carboniferous Rocks of the Hunter River District. Carne's geological contributions to the report of the Tin-mining Industry and Andrew's report on the Drake Goldfield provide material that is vital to a consideration of common stratigraphy and orogeny as applied to the two States. Andrew's paper on the "Structural Relations of Australasia, &c." (Journal of Geology) deals prominently with the history of the Permo-Carboniferous as understood at that period, and indicates an unfinished problem. Benson has made very notable contributions which bear critically on the subject-matter in the suite of papers on the Great Serpentine Belt, as well as the "Census and Index

of the Burindi Fauna" and "Materials for the Study of Devonian Palæontology." The papers of Sussmilch, Brown and Dun, and also Osborne, bearing on the relationship of the Kuttung and Permo-Carboniferous, are specially relevant to the problem of defining the age of the strong orogenic movement of Upper Palæozoic age which affected portion of the present coastal strip of Eastern Australia. Etheridge and Dun's palæontological contributions to the marine fauna of the period, as well as those of Walkom on the palæobotany of the Burindi and Kuttung, have been extensively used. Lastly, Dr. W. R. Browne's recent address on the History of Palæozoic Igneous Action in New South Wales has proved most helpful and suggestive.

The writer does not wish to pass over without comment the splendid *exposé* of the "Période Anthracolithique" by Haug. Many of his dicta seem to be worth keeping in mind in considering Australian problems, and the following extract (though requiring modification due to subsequent specialised work on the faunas of the period) appears still applicable to Queensland in general principle as to the difficulties which seem to have arisen in the past over our faunal records, possibly on account of certain relatively long-ranging forms:—

"It is scarcely possible to characterise any of these stages (i.e. *Moscovien, Uralien,* &c.) by a collection of species belonging to different groups of invertebrates which constitute a distinct fauna from that of the neighbouring stages. It is rare, especially regarding the brachiopods which predominate almost always in individual numbers, that a given species may be confined to an exact horizon and does not pass from one stage into the following. Some even traverse the whole (i.e. *Anthracolithic*) Series without any modification. The Zoantharia, the lamellibranchs, and the gasteropods give still less satisfactory results." (Traité de Géologie, vol. ii., p. 753, E. Haug. Transl. J.H.R.).

The very recent statement of Schuchert as follows—

"It has long been well known that the Upper Carboniferous marine faunas of the northern hemisphere go into the Permian with abundant development and without much change but that in Middle Permian a great change sets in among them" (Bull. Geol. Soc. of America 1928, vol. 39, No. 3, p. 777)—

appears further in support of the view taken up herein by the writer that many of our recognised Permo-Carboniferous species (e.g., *Trachypora wilkinsoni, Protoretepora ampla, Martiniopsis subradiata,* to quote only a few) are far from being restricted in range, and do assist in establishing a transition fauna between our undoubted Carboniferous and Permian deposits.

In conclusion, thanks are recorded to Sir Edgeworth David and Mr. C. A. Sussmilch for suggestions on certain portions of the paper; to Mr. F. Chapman, who at the instance of Sir Edgeworth David corrected the palæontological nomenclature; to my colleague, Mr. C. C. Morton, for his field endeavours recently to elucidate relationships between the Silver Valley *Ancimites* beds and the Hodgkinson Series; and to Dr. F. W. Whitehouse, who supplied several fossil lists and kindly examined the specimens of Star River *Spirifers* collected by the late Dr. R. L. Jack.

III.—TABLE OF SUGGESTED CORRELATIONS.

	QUEENSLAND CENTRAL.	QUEENSLAND COASTAL.	NEW SOUTH WALES NORTH-EAST.
JURAS (in part) ..	..	STANWELL COAL MEASURES, &c.	CLARENCE
TRIASSIC	CARBOROUGH SERIES	..	HAWKESBURY
	Conformity and Overlap	**Angular Unconformity**	
PERMO-CARBONIFEROUS	UPPER BOWEN	..	NEWCASTLE TOMAGO
	MIDDLE BOWEN Marine Series Collinsville Coal Measures	MIDDLE BOWEN Marine Series (?) Collinsville Coal Measures	UPPER MARINE GRETA
	LOWER BOWEN Volcanic and paralic	LOWER BOWEN Volcanic and paralic	LOWER MARINE (of Hunter River)
UPPER CARBONIFEROUS	Angular unconformity BREAK	GYMPIE FORMATION { Monkland Series / Neerkol Series }	Drake, Vegetable Ck., Kempsey, &c. (in part) KUTTUNG
LOWER CARBONIFEROUS	UPPER STAR FORMATION (= Upper Drummond)	ROCKHAMPTON SERIES (Texas, Rockhampton, Cania, &c.)	BURINDI
		(Probable conformity)	
UPPER DEVONIAN	LOWER STAR FORMATION Mt. Wyatt, Star R. (= Lower Drummond)	*Lepidodendron australe* beds of Canoona, &c.	LAMBIAN and BARRABA
MID-DEVONIAN	Ukalunda		

HISTORICAL SYNOPSIS.

(Read in ascending order.)

PERMO-CARBONIFEROUS	(6) Strong folding in S. E. Q'ld. Partially transitional sedimentation west thereo up to Triassic with local overlap and angular unconformity. (5) General regression of sea followed by long periodic coal-forming age. (4) Upper marine and chief glacial epoch of Bowen River, &c. (3) Collinsville coal period. (2) { Lower marine and glacial beds of Springsure, &c. / Apogee of Upper Palæozoic vulcanicity in Q'ld. } (1) { First record *Glossopteris* flora. / Partial regression of sea, disconformities, boulder conglomerates. }	
UPPER CARBONIFEROUS	(2) Marine sedimentation in S. E. Q'ld. with glacial boulders at Silverspur and Gympie. Volcanic (andesitic) action marked but spasmodic. First appearance of East Australian Permo-Carbonferous fauna (1) Local disconformities (e.g. Lion Creek, &c.).	Probable freshwater sedimentation and intercalated rhyolites, &c., north of Broadsound
LOWER CARBONIFEROUS	Rockhampton marine series in S. E. Q'ld. with important (andesitic) vulcanicity. Oolitic and crinoidal limestones, cherts, shales, &c.	Drummond Movement in Central and Northern Q'ld. Volcanic eruptions. Freshwater deposits probably widespread in Central and Northern Q'ld. (Upper Star Series), *L. veltheimianum* period.
UPPER DEVONIAN to MIDDLE (?) DEVONIAN	(5) Conformable succession to Lower Carboniferous and regression of sea to S. E. Q'ld. (4) Andesitic tuffs and flows. (3) Marine to paralic sedimentation (Lower Star Series) apparently widespread in Coastal and Central Queensland, Red beds, *L. australe* period. (2) Limestones, rhyolites, &c., in the Rockhampton district probably of Mid-Devonian age. (1) Strong angular unconformity indicated at base of Burdekin Limestones.	

Palæontological Records.

With each of the series as described in the succeeding parts a list of fossils will be found. They are admittedly to some extent unsatisfactory; for instance, there is much new and undescribed material available for working up, particularly from the Bowen Marine Series.

It is considered that the productid group of what appears to be the Upper Carboniferous sequence may prove an exceedingly important one, possibly represented on present evidence by at least six distinct species in Queensland and New England (N.S.W.) which have not yet been described, and whose relationships may be expected to have an important influence on portion of the thesis of this paper. Then there seem difficulties or doubts regarding former palæontological determinations that need clearing up, such as that, possibly, of the *Heliolites porosa* of the Broken River beds; that of the form attributed to *Productus* (?) *subquadratus* of Lake's Creek, which appears to differ very greatly from the Mount Britton and Yatton species; such also as the presence of a described Carboniferous genus of trilobites in the Lower Star, that on all the other evidence seems to range from Middle to Upper Devonian. Descriptive palæontology in Queensland needs an impetus to keep pace with fieldwork in the Upper Palæozoic rocks at least.

The records are restricted (with a view to making them more dependable) in that only determinations or records of recognised palæontological authorities are included (mostly the official palæontologists of New South Wales and Queensland) with a few exceptions, in which the qualifying (p) refers to what is regarded as a provisional determination.

IV.—THE STAR FORMATION.

Bryan's excellent Glossary of Queensland stratigraphy gives the following information with accompanying references,[4] so saving the need of recapitulation of the latter:—

"Etheridge Senior in 1872 placed the Star Series in the Devonian; Jack in 1892 placed it above the Gympie Formation in the Permo-Carboniferous system; Dunstan in 1913 placed the Star in the lowest division of the Permo-Carboniferous and *below* the Gympie Formation. David in 1914 assigned it to the 'Carboniferous'; Dunstan in 1916 regarded it as equivalent to the Drummond Series and Rockhampton Series, all being placed in the Carboniferous. *Synonyms*: Star Beds and Star Series."

Age.—Upper Devonian to Lower Carboniferous in conformable sequence. It could be considered as descending to the Middle Devonian with the inclusion of the Ukalunda beds. The change in age advocated is not such a radical departure from the Permo-Carboniferous of Jack as would at first sight appear, for he regarded the lower beds of the Permo-Carboniferous as homotaxial with the Carboniferous of Europe.[5] Further, regarding the relative ages of the Gympie and Star, Jack[6] stated that there was not much indication as to which was the older. From the fact that the Gympie was almost always highly inclined, and

to some extent metamorphosed, while the Star was generally little disturbed and little altered, he surmised that the latter was unconformably related to the former, although no section had revealed their relationship to one another. This point is clear to-day, because the Queensland Geological Survey's work on the Permo-Carboniferous coal measures has revealed that all known fossiliferous Gympie localities of the old maps are within the coastal zone of the late-Permian folding, with the exception of the Ukalunda "Gympie" beds which have latterly been indicated to be of *Middle* Devonian age. On the other hand, all Star areas defined by Jack are inland from this zone, or from a north-and-south prolongation of it, and apparently have not been noticeably affected by it.

The areas which Jack considered as the type districts of the Star Formation were the Star River, Keelbottom, Harvest Home, and Mount Wyatt.

It is necessary to here examine several old references to the sedimentary rocks of the Mount Wyatt area, which fortunately have been re-examined. The first by Daintree[7] stated—

". . . a series of blue and grey slates and shales around Mount Wyatt. On the upturned edges of these rest the slightly inclined grits and sandstones of the Upper Devonian *Lepidodendron* beds. Specimens from this locality . . . determined by Professor McCoy consisted of *Chonetes sarcinulata*, *Orthis* allied to *rustica*, *Receptaculites*, *Leptæna* sp. indet. ; and were referred by that authority to the Upper Silurian."

Jack, after examination of the Mount Wyatt district, did not accept the Silurian age of the Mount Wyatt beds, and after stating that he observed both Star and Gympie (apparently Ukalunda. some 4 miles W. of Mount Wyatt field, J.H.R.) beds in the neighbourhood, he thought it probable that the *Chonetes*, &c., beds belonged to the Gympie.[8] The statements of Daintree seem inexplicable in the light of a general examination, made by the writer, of the Mount Wyatt field in 1928, more particularly around the mountain of that name, close to which a marine horizon was discovered which is probably one of Daintree's localities—"Wynn Creek." Associated with this, in a considerably folded series with dips ranging to 60°, *Lepidodendron australe* was found rather frequently. The only unconformity observed in the field was that formed by horizontal beds of red grits, "billy," &c., presumably of Cainozoic age, lying on the folded *Lepidodendron* beds. The "slightly inclined *Lepidodendron* grits and sandstones" of Daintree, lying unconformably on an older series, were not substantiated in an area of about 60 square miles roughly mapped around Mount Wyatt. Further, Daintree[9] stated that in the upper sandstones of the Devonian of tropical Queensland *Lepidodendron* is associated with *Spirifer disjunctus*, and that Mount Wyatt may be taken as the representative of the Upper Devonian. Thus there is reason for a strong presumption that *S. disjunctus* may have been found then at Mount Wyatt, and not presented to the Melbourne Museum in the collection that was described by McCoy, and the statement only tends to confirm the result of recent work, in that this species has just been "refound" associated in the *folded* "lower" beds at Mount Wyatt associated with *L. australe*, and not in the "upper" section there.

A re-examination by Chapman[10] of Daintree's original specimens named by McCoy, showed that *Receptaculites australis* was present, and this specimen also contained impressions of *Leptæna analoga* and *Fenestella multiporata* (de Kon), thus disposing finally of the supposed Silurian age of the beds referred to. It is of interest that Mr. J. Peacock, manager of Hidden Vale Station, handed to the writer a beautiful specimen of *Receptaculites australis,* probably the only one available in Queensland at present, which is reported to have come from Mary Creek, about 7 miles N.N.E. of Mount Wyatt. Prospectors report the occurrence of *Lepidodendron* and fish remains in that neighbourhood. This seems merely to confirm the record of *R. australis* by Chapman in the Lower Star beds, and therefore it appears fairly safe to conclude that this species may range upwards to the Upper Devonian.

From the neighbouring district of Ukalunda, the writer next found a collection of fossils (including the cup-coral, *Calceola,* identified by Whitehouse) in the exact locality in Gordon Gully, near the old silver-lead mines, from which Jack obtained some poorly preserved material which he provisionally determined as *Spirifer, Productus,* &c., and placed in the Gympie. The Ukalunda beds are excessively intruded by granite, peridotite, and quartz porphyry, and the fact that they strike W.N.W. to N.W. (angles of dip 30° to 45°) in contradiction to the N.E. strike of Mount Wyatt does not count for separation from the Star as against the typical green, Lower Star shales which occur at places in the area in addition to the suite of Devonian fossils obtained. From the rock matrix and species obtained, they must certainly be on a different horizon to the fossil bed of Mount Wyatt. In a direct line, the marine fossil locality of Ukalunda is about 6 miles W. of that at Mount Wyatt, with much granite in between.

The features at Mount Wyatt thus seem clear. Jack regarded the beds there as co-types of the Star River Formation, and the writer found them to agree well lithologically with certain beds as described in other type areas, so that the fauna at Mount Wyatt is of very great interest. The geological section there consists of a lower and upper division, based as yet only on a marked lithological difference, which are conformably related. Both are considerably folded and most extensively intruded by granites, porphyries, &c., in many areas. The folding adheres to a N.E. axis with a disturbed line which gives N.W. strikes by warping and, possibly, faulting. The lower consists of a calcareous series, the characteristic colour of which is a dirty yellowish green. Common types are finely laminated green and blue shales, sandstones and grits, and tuffaceous sandstones with nests of calcite. There is often a resemblance to the greenish rocks of the Drummond Range series.

The net results are that the lower division of the Mount Wyatt beds of Jack are of Upper Devonian age, that it is of considerable territorial extent in the surrounding country, and can be considered to probably include the former "Gympie" area of Jack at Ukalunda,

apparently ranging in age down to the Middle Devonian. Its thickness is unknown owing to considerable folding, and to the limitations of fieldwork not revealing its base, but it is at least some thousands of feet.

The upper division of the Star Series of this type district is marked from the lower by a sudden change to fine-grained, light-coloured, and non-calcareous sediments, which rest in a perfectly conformable sequence on the lower green rocks. A slight uprising is implied, apparently introducing freshwater conditions, for the green and blue sandstones and shales never appear in the next 500 ft. to 1,000 ft. of sediments traversed upwards on the western slopes of Mount Wyatt. The upper series consists of a monotonous succession of grey to light-pinkish shales and sandstones which seemed to be devoid of any organic remains on the mountain. There are occasional layers of yellow to buff sandstones in the upper shales, which apparently afford the only resemblance to sandstones in the Upper Drummond Series, but also to the buff sandstones of Elgin Downs containing *Lepidodendron* of Lower Carboniferous type, according to Walkom's opinion.[11] Eight miles east of Mount Wyatt the upper shales are developed on Hidden Vale Range, so implying a wide distribution infolded with the lower series. The thickness is unknown, but may greatly exceed 1,000 ft. No organic evidence of the Lower Carboniferous age of the upper series on the Mount Wyatt field itself has been found. Collateral evidence, such as their succession on Upper Devonian after a presumed slight and gradual crustal uplift, and some lithological grounds for uniting them with the *L. veltheimianum* beds of Hannam's Gap and Elgin Downs, suggest that they continue into that period in this district.

Mount Wyatt and Star River Comparisons.

Jack having correlated the Mount Wyatt beds with those of the Star River district (Star, Dotswood, &c.) which lie 80 to 100 miles N.N.W. from the former, it is logical to assume that the latter may also descend into the Upper Devonian. There has been no opportunity for re-examination of these beds, and only an analysis of the relationships and dissidences between the two, on the basis of published data now available, can be made. In lithology, nothing was seen at Mount Wyatt to compare with the conglomerates and sandstones of Star Station and Dinner Creek (*not* Stanwell), which rest on granite.[12] The point has no present significance, for the lowest beds at Mount Wyatt are not known, and the granites there are all *post*-Star, while those of the Star-Burdekin district are *pre*-Star, according to Jack. Legitimate doubt may be expressed as to whether the last observation applies generally, owing to the intrusion by granite of the nearby Devonian limestones of Reid River, recorded by Morton.[13] The occurrence of green and bluish calcareous shales are common to both areas, and are of significance allied to a fauna in which are described forms common to the Devonian and Carboniferous. *Lepidodendron australe* is abundant, and its occurrence with proved Devonian rocks in Queensland, rather than with proved

Carboniferous, makes it seem at least doubtful whether it has a higher range than is recognised in New South Wales. The absence of assurance that any of the *Lepidodendron* from the Rockhampton Series conforms to *L. australe* rather strengthens this doubt. In the Little Star there is Jack's reference[14] to *Orthis, Chonetes,* and *L. australe,* with which to compare Daintree's Mount Wyatt specimens submitted to McCoy. However, there are records of *Phillipsia rockhamptonensis* and *P. stanvellensis,* a Carboniferous genus, in these beds which otherwise appear equivalent to the Upper Devonian section of Mount Wyatt. Comments as to their validity are appended to the Star Formation faunal lists (*postea*). Finally, in the Queensland Geological Survey collections there is a specimen showing a large group of *Spirifer disjunctus* from the Star beds at Mount Joseph, in the Star type area, which Dr. Whitehouse considers indistinguishable from the species in the Lambian series of New South Wales.[15]

From Corner Creek, *Fenestella multiporata* (de Kon) is described by Etheridge, and this is the only record of this species in Queensland besides the one found on the specimen of *Receptaculites australis* from Mount Wyatt. It occurs, however, in three Lower Carboniferous localities in New South Wales, as cited by Benson. The genus occurs in New South Wales Devonian rocks, but apparently no species have been determined.

Apart from the records of *Phillipsia,* the weight of evidence seems wholly in favour of an Upper Devonian age for the Star River areas. Jack stated—

> "There can be no doubt of the identity of the lower basin of the Star River with the Mount Wyatt beds";

and—

> "the Star beds are Upper Devonian if not Lower Carboniferous."

Correlation with Drummond Series.

The prevailing conception regarding the Drummond Range section (where the above series is so finely exposed) in Queensland geological literature appears entirely deficient and, in some cases, wrong. The limited Hannam's Gap section is well known and much cited, but, unfortunately, Jack has given an erroneous impression of the Drummond section by stating—

> "At Bogantungan is the axis of a synclinal trough and as far eastward as Withersfield (*i.e., a 20-mile interval*) the dip is towards the west."

This does not accord with the Zamia Range anticline to the east of Bogantungan, nor with Jensen's statements that the Star beds in this portion of Queensland are considerably folded and unconformable with the overlying Lower Bowen Series[18]—also "that they cannot be called intensely folded."[19] Jensen's statements are confirmed on these points, and Reid and Morton's diagrammatic Central Queensland section[20] shows this broad open folding and unconformability with the Bowen series. The sections on the Drummond Range and its eastern offshoot—

Zamia Range—just east of Bogantungan, are, without much doubt, among the most imposing mountain sections of regular stratigraphy that it is possible to see in Queensland. The regularity of dip and strike has given rise, in the former, to a series of tabular layers vanishing imperceptibly in the distant perspective, which recall Murray's description of the tabular eminences and park-like character of the Mansfield beds in Victoria, generally considered of the same age. The Zamia Range is a broad anticline—a structural range with reversing dips ranging from angles of about 20° to 35°. An outline of the Drummond section thus shows moderately folded rocks in which Dunstan[21] has described conglomerates and sandstones (dipping steeply) near Anakie, apparently in its basal division, and these appear to be followed by the lower series of green sandstones and shales between Withersfield and Bogantungan, which is characterised by thin "brick-red" beds of shale and sandstone representing, possibly, the most striking colouration in Queensland stratigraphy. In the upper section of the range west of Bogantungan there appear to be no red beds, but green and purple shales are conspicuous and, near the top, yellowish to buff sandstones with *L. veltheimianum* are prominent. There is only an arbitrary and assumed boundary between the upper and lower sections. The lower is almost unknown, but is marked by the red beds. The upper section contains abundant *Lepidodendron veltheimianum* at Hannam's Gap, where there is a noted horizon of this species, but *L. australe* is absent in it. *Aneimites austrina* is described and recorded from Mount Budge (or Mudge, J.H.R.), which lies 33 miles south by west of Bogantungan, by Etheridge Junr. This mountain appears to lie geographically in the central core of the range, and thus seems likely to occur in the upper series of the Hannam's Gap synclinal, but actually there does not appear to be evidence as to its field relations to the Hannam's Gap beds.

Against a disposition to regard this bed as equivalent of the Kuttung *Aneimites* beds in New South Wales, the following may be considered:—(1) Etheridge's Drummond Range species has not been recorded there; (2) as far as known a similar volcanic series does not occur; (3) the *Rhacopteris* flora is generally regarded as essentially Lower Carboniferous; (4) the great unconformity between the Drummond Series and the Lower Bowen in that region must evidently correspond essentially to Kuttung time.

Scales and other fish remains occur throughout the upper section of the Drummond Range, and are known also below the highest red bed. The most striking description of the character of the beds in the Hannam's Gap section is undoubtedly that of the late James Smith, quoted by Jack.

There is thus no reason to doubt the Lower Carboniferous age of the upper division, an age which has been accepted rather generally for the series as a whole. As to whether the lower section descends into the Upper Devonian, as does the type Star, is a matter for consideration of rather scant evidence.

Thickness.—As to the thickness of the Drummond Section it is estimated that, for the upper series, it is about 2,000 ft. from the highest red bed to the top bed at Hannam's Gap; erosion has then terminated the section. There is no reason to doubt that, taking the lower section downwards from, say, the top red bed, near Bogantungan, it is of very great thickness. There is no data on which to compute it, but the section from the Zamia Range to Bogantungan, it is thought, might possibly comprise from 5,000 ft. to 7,000 ft., and there are almost certainly additions of lower beds to add thereto.

Lithology.—The beds are very similar to the marine Star beds of Mount Wyatt, but as the upper beds in which no marine fossils have been found are also like those, a doubt is raised as to whether the Lower Star is wholly marine. The red beds of the Lower Drummond have possibly their nearest approach lithologically to the red beds of Dotswood, of supposed Upper Devonian age, described by Jack and compared by him to the Lower Old Red of Perthshire.

Lepidodendron australe is recorded in the series in the following localities:—Medway River, Bogantungan, and Drummond Range. A notable locality for it would appear to be at Mount Beaufort,[21a] some 20 miles west of the Drummond Range, in the Alpha district. A section of the Drummond Range indicates all the western and eastern beds of the series as being more probably of the Lower division. Unfortunately, none of the above horizons can be placed, and to that extent we are in doubt. It appears significant that in the very abundant bed of *Lepidodendron* at Hannam's Gap, almost the highest bed developed there, not one specimen of *L. australe* has been recorded.

The lithological resemblance to certain Lower Star beds, the occurrence of *L. australe* somewhere in the lower portions of the undivided section, and the apparent great thickness of the series indicate almost certainly that the lower beds descend into the Upper Devonian.

In addition to the above evidence, the presence of fish remains (*Palaeoniscus*), &c., in the Star and Drummond is referred to by Jack in these terms:—

> "These fish remains form an additional and strong link connecting the Drummond and Star beds."[22]

Summarising, the following points appear to point quite definitely to the Upper Devonian age of the lower section:—

(*a*) Lithological resemblance to certain Lower Star beds, including Red Beds at Dotswood.

(*b*) The apparent great thickness of the whole series; a probable minimum before erosion would appear to be of the order of 10,000 ft.

(*c*) The presence of *L. australe* in sections to the east and west of the Hannam's Gap section where it does not occur with the prevailing and abundant *L. veltheimianum*.

(*d*) Evidence favouring an area of continuous and uninterrupted sedimentation with the Mount Wyatt Star Beds which range down into the Upper Devonian at least.

Hodgkinson Series.

There have been many views stated in the past regarding the age of this series, but all have been within the range Devonian to Permo-Carboniferous. It seems to-day very strange that this should have been so, for Etheridge Junr.[23] gave a clue to it very exactly in his determination of the two identifiable corals *Pachypora* sp. ind. and *Cyathophyllum* sp. ind. (figd.) from the Beaconsfield limestone, which occurs in this series. His description of the latter form showed Devonian affinities *contra* to Carboniferous, and, in addition, *Pachypora* does not appear to occur above the Devonian in Eastern Australia.

Jack[24] only placed the series provisionally in the Gympie. Ball[25] considered it to be Carboniferous following the discovery of *Lepidodendron* at Mount Mulligan. Jensen[26] regarded it as Devonian, apparently on Jack's record of *Lepidodendron australe*.

The writer has briefly examined the section of the Hodgkinson Series exposed between Mount Mulligan and the Hodgkinson River, a distance of about 2 miles. Very fine railway sections are exposed in this area, and it was concluded that there was a marked resemblance in them to certain Star or Drummond beds. The rock sections consist of greywackes, grits, and well-defined bluish-black shale beds. The former two rocks predominate and are neutral coloured with tints of bluish grey, brown, buff, and yellowish green. The sharp interstratification of the hard rocks with the shale bands, which is prevalent, is a very marked feature, possibly without significance, of the Drummond sections, which has given rise to the notable tabular beds of that range. The grits and greywackes are often very hard, but the shales do not appear to be indurated. It is realised that the above comparison only takes force because Jack has recorded *L. australe* from the Hodgkinson Series, and that species is the characteristic fossil plant of the Lower Star Formation, and not of any other apparently. Why, then, did Jack not recognise this formation as Star? Possibly (1) because they are more tilted and disturbed than any Star beds known; (2) because this strong tilting has produced an entirely different topography from most Star areas, e.g., dominant lines of "hogbacks"; (3) because the very fine Mount Mulligan railway cuttings showing illuminating sections of strata in this series were not then available.

The fossil evidence points to the series being largely Lower Star, and therefore Upper Devonian, but cognisance must be taken of the fact that, in accordance with stratigraphical relationships advocated in this paper, there may be a conformable sequence contained, ranging probably from Middle Devonian to Lower Carboniferous inclusive.

The Hodgkinson Series appears, in parts at least, the most disturbed section of the Star Formation known, despite the apparent absence of intrusive granites where it is most disarranged. The *Aneimites* beds of Silver Valley (Newellton), which appear to be either of Upper Star or Kuttung (N.S.W.) age, are only gently dipping, as shown by Stirling,

and lie unconformably on a very folded and considerably altered series which was considered by Skertchly, and now is by Morton, to equal Chillagoe. There has been doubt in Queensland as to whether the Hodgkinson Series is folded with the lower metamorphosed Silver Valley rocks or with the Carboniferous *Aneimites* beds there, and this doubt has been expressed by Bryan.[28] Bearing on this we may consider that (1) the Silver Valley Carboniferous bed, as mapped by Stirling, is an outlier of only $1\frac{1}{2}$ by $1\frac{3}{4}$ miles extent, and deductions as to the folding of the series generally, on its attitude, would have little value, more so as the Star beds with *L. australe* are gently to moderately folded over bigger areas in the Burdekin district progressively further south; (2) *Aneimites* and *L. australe* are assumed to be in a conformable sequence at the Drummond Range; (3) the Hodgkinson Series at Mount Mulligan is not metamorphosed by folding, as the lower series (considered Silurian), at Silver Valley, has been to flexured and slate rocks, on the statement of Stirling.

The great tilting and disturbance of the series along the Mount Mulligan line may perhaps be partly attributed to the posthumous block faulting, described by Ball, which dropped the Permo-Carboniferous and Trias beds into the older series. The latter are often vertical, and many local faults were noted by the writer, as well as divergences in strike. The evidence quoted above suggests grounds for considering the series as folded not later than about the Middle Carboniferous, and as being younger in age than the folding movement of (?) Lower Devonian age, to which the writer in the present state of our information ascribes tentatively the folding of the Chillagoe, Broken River, Silver Valley metamorphics, and Clermont slates, &c.

There has been a consensus of opinion of field geologists that appeared to support this as follows:—

Jack[29]—

"... the coastward portion (*of the Hodgkinson Goldfield*) has suffered metamorphism in a much greater degree than the inland portion ... if both existed side by side, it is not easy to see how one escaped the metamorphism which the other underwent";

Ball[30]—

"They are thin bedded and seldom very much altered, and sometimes it is difficult to distinguish them from the coal measures except by their dip which is mostly high"; and

Jensen[31]—

"The Series is usually found dipping steeply, but folded in a regular manner. Intense plication as in the Chillagoe Series typically absent."

The conclusions of the most recent observer, Mr. Morton, in a series of admittedly rather superficial examinations of the Silver Valley, Chillagoe, and Northcote-Beaconsfield districts of the Hodgkinson, are not in accord with the above deduction. He describes the Silver Valley metamorphics as identical with Chillagoe, thus supporting Skertchly, but the former has phyllites that have never been described from the Hodgkinson. Between Northcote and Beaconsfield the supposed Star beds, he considers, resemble the Silurian, and he has not been able to

notice a structural break or marked difference in metamorphism, but not having seen the section at Mount Mulligan it is possibly doubtful whether the area he has seen is representative of Jack's Hodgkinson Series. His examination left the impression that possibly there was no orogeny between Chillagoe and Hodgkinson, but it is definite between Chillagoe equivalents and the *Aneimites* beds as first noted by Stirling. In the light of this opinion, re-examination of the above statements, seemingly opposing this interpretation, by Jack, Ball, and Jensen must be made. Jack's comparison refers evidently to the Mareeba-Barron Falls Series containing mica-schists that appear certainly pre-Chillagoe according to Morton, and so the statement apparently, after all, is not cognate. Ball's statement is exceedingly difficult to overcome without an intervening Chillagoe-Hodgkinson diastrophism. Morton, in variance to the quoted statement of Jensen, does not regard the Chillagoe Series as showing generally intense plication, but regards the folding as comparable in degree to that of the Hodgkinson (?) observed by him near Northcote. Jensen in another statement (*ibid. p.* 43) allows strong plication only in regions of special stress in both the Chillagoe and the Hodgkinson, so that his first quotation must be discounted as indicating marked difference of diastrophism, if any, between the two. In the light of this a possible Lower Devonian orogeny in the Cairns hinterland must be regarded at present as indefinite and awaits further field investigation, but if we can accept the identity of the Silver Valley volcanics as that of the basal volcanics in the Mount Mulligan Permo-Carboniferous section (see pp. 26 and 77-78) it would appear that all orogeny in North Queensland must be earlier than the *Aneimites* beds of Silver Valley.

The unconformity shown in Ball's section as between the Hodgkinson and the Mount Mulligan Permo-Carboniferous, the latter possibly including a Lower Bowen volcanic stage, would be in keeping with the Middle Carboniferous folding movement of the Drummond Range as to age and the relationship there between Lower Carboniferous and Lower Bowen.

Fossils of the Hodgkinson Series.

Lepidodendron sp.	Mount Mulligan
L. australe	Thornsborough)
Cyathophyllum sp. indet.	(Beaconsfield)
Pachypora sp.	(Beaconsfield)
Retzia sp. (prov. det.)	(Beaconsfield)

Other Star Areas.

The *Aneimites* beds at Silver Valley (Newellton), Herberton district, N.Q., have long been known, thanks to Stirling's investigations. Very recently my colleague, Mr. Morton, visited this area and has most kindly supplied the following notes on it:—

"The rocks of the Carboniferous section at Silver Valley containing *Aneimites* are limited apparently to one small outlier, little more than a mile across. As shown by Stirling they unconformably overlie a highly folded series of which many members at least show considerable metamorphism, such as schistose slates and dense crystalline

limestones. The basal Carboniferous beds, resting on these, consist of boulder conglomerates perhaps to 200 ft, thick and over these lie sandstones and grits with one or more thin shale beds with *Aneimites*, &c. The whole Carboniferous sedimentary section would probably not exceed 300 ft. The rocks are sub-horizontal but close to an intrusive (?) junction with a younger volcanic series they dip, locally, as high as 55°. There is no evidence of folding in these beds but they are intruded sparsely by dykes of acid rocks apparently related to effusive masses near-by and in two instances the sedimentary rocks are overlaid by outliers of fragmental volcanics undoubtedly belonging to the massive series of volcanics alluded to. These in appearance resemble the Featherbed Range (Koorboora) volcanic rocks which are recorded by Ball as containing acid tuffs or tuffaceous sandstones in which some thin seams of impure coal occur and discussed by him in reference to the basal volcanic series at Mount Mulligan, so that the Silver Valley volcanics are probably of Lower Bowen age but no organic evidence of their age has been found. There would appear to be no evidence of folding movements occurring in the period between the deposition of the *Aneimites* beds and the overlying volcanic series at Silver Valley."

The Silver Valley beds with *Aneimites ovata*, though a very thin section, seem clearly equivalent to some portion of the Kuttung Series of New South Wales and thus may correspond to some lower portion of the suggested Gympie rather than the Upper Star Series.

The Pascoe River beds, Cape York Peninsula, described by Morton,[32] are presumably of Upper Star age, for Walkom stated that the Lepidodendroid stems and *Cordaites* were sufficient to enable a Carboniferous age to be assigned to these beds. They are folded and excessively intruded by quartz-porphyry and are altered to the extent of considerable induration of the sandstones and shales which may possibly be largely ascribed to the effects of intrusive contacts (*fide* Morton).

For the sake of convenience the preceding beds have been allowed to remain in the Upper Star in this paper, for the exact age of the horizon of the Lower Kuttung seems to be an undecided point in New South Wales. It is, however, possible that the Queensland beds in question may be equivalent to some marine horizons of the Gympie Formation (Neerkol Series).

At Cannindah, Upper Burnett, there is a conformable sequence from *Lepidodendron australe* beds (Lower Star?) to the Cannindah limestone on the Lion Creek horizon of the Rockhampton Series. The whole section is folded in a large anticline with rather steep dips and is faulted up against Jurassic coal beds on the west.

Other possible areas where Lower Star marine beds might perhaps be expected are to the north and south of Rockhampton, where railway cuttings expose beds considered superficially like those of the Hodgkinson Series in the Kooltandra and Ambrose districts respectively. Both of these lie in the Devonian belt shown on the latest geological map prepared of the State, and possibly may prove to be Upper Devonian. The beds at Canoona with *Lepidodendron australe* should perhaps be provisionally classified as Lower Star.

Volcanic Rocks.—Records of extrusive rocks appear to be negligible in the Star as distinct from the Rockhampton marine beds. The most significant occurrence, economically, is the series of andesites (porphyrites) of Keelbottom copper-mine described by Card[33] as of

close resemblance to the "diabase-porphyrites" from the Lake Superior copper-mines. The Keelbottom volcanics have been worked to some extent for native copper, and recent inquiries indicate possibility of re-working. Jack[34] describes this section as consisting of dolerites intercalated with sandstones and indicates a considerable extent of them, but the horizon in the Star Formation is apparently not known. Tuffaceous sandstones have been recorded in the Lower Star at Mount Wyatt. Andesitic lavas and tuffs pass up from the *Lepidodendron australe* beds of Cannindah into Lower Carboniferous (Rockhampton) rocks. Morton associates some of the highly altered igneous rocks as volcanic (though some are later intrusions) with the Pascoe River beds.

TABLE I.

FOSSILS RECORDED FROM AREAS GROUPED IN THE **LOWER STAR** FORMATION.

	Refs.	Star River.	Fanning and Keelbottom.	Mt. Wyatt.	Ukalunda.	Hodgkinson Field.	Drummond Range.
Receptaculites australis Salter	(iii.) (v.)	..	..	x (f)			
**Cyathophyllum* sp. ind.	(ii.)	..	..	..	..	x (f)	
Pachypora sp. ind.	(ii.)	..	..	..	..	x	
Aulopora (?) sp. ind.	(v.)	..	..	..	x		
Calceola sp. nov.	(v.)	..	..	..	x		
(?) *Romingeria foordi* Eth. fil.	(v.)	..	..	..	x		
Actinocrinus sp. ind.	(ii.)	x (f)					
Fenestella multiporata de Kon	(ii.) (iii.)	x (f)	..	x			
Fenestella sp. ind.	(v.)	..	..	..	x		
Lingula (?)	(v.)	..	..	..	x		
Leptæna analoga Phill.	(ii.) (iii.)	x	..	x			
Chonetes sarcinulata	(ii.) (iii.)	..	..	x			
Chonetes cracowensis Eth.	(ii.)	x (f)					
Chonetes sp.	(ii.) (v.)	x (f)	x (f)	..	x		
Schizophoria resupinata Martin	(ii.)	x					
Schizophoria sp.	(v.)	..	..	..	x		
Orthis aff. *rustica*	(ii.) (iii.)	..	..	x			
Rhynchonella pleurodon Phill.	(vi.)	..	x				
Spirifer disjunctus Sby.	(v.)	x	..	x			
**Spirifer bicarinatus*	(ii.)	x (f)	x				
Spiriferina sp. ind.	(ii.)	x					
**Reticularia urei* Fleming	(ii.)	x					
**Retzia radialis* Phill.	(ii.)	x					
Athyris (?)	(ii.)	x					
Nuculana sp. ind.	(ii.)	x (f)					
Nucula (?)	(ii.)	x					
Aviculopecten sp.	(ii.)	x					
Entolium sowerbii McCoy	(ii.) (vi.)	x					
Pterinea sp.	(v.)	..	..	..	x		
Naticopsis sp.	(ii.)	x					
Bellerophon sp.	(vi.)	x					
**Porcellia Pearsi* Eth. fil.	(ii.)	x (f)					
Orthoceras ..	(ii.)	x					
Dalmanella cf. *lenticularis* Vanuxem	(v.)	..	..	..	x		
Leptostrophia sp.	(v.)	..	..	..	x		
Euchondria sp.	(ii.)	x					
Beyrichia varicosa T. R. Jones	(ii.)	x (f)					
†*Phillipsia stanvellensis* Mitchell	(iv.)	x (f)					
†*Phillipsia rockhamptonensis* Mitchell	(iv.)	x (f)					
Palæoniscus Randsi Eth. fil.	(ii.)	..	..	x	..	..	(?)
‡*Lepidodendron australe* McCoy	(i) (ii.) (v.)	x	..	x	..	x	x
Lepidodendron sp. ind.	(ii.)	x					
Cyclostigma sp. ind. (near *C. kiltorkense*)	(ii.)	..	..	x			
Dicranophyllum australicum	(ii.)	..	x (f)				

* Species thus marked are those that Etheridge regarded (amongst his determinations) as indicating more resemblance to Devonian forms than to Carboniferous.

† With regard to the recorded occurrence of the genus *Phillipsia* in these beds, it is ascertained that the presence of *P. rockhamptonensis* is alone based on an apparently incomplete and deformed pygidium (see Plate L., fig. 9, Proc. Linn. Soc. N.S.W., vol. xliii.). The specimens on which the description of Mitchell's new species is based come from an undescribed locality in the Rockhampton district. With regard to *P. stanvellensis* (surely an inappropriate specific name for a Star River specimen) this is based on a perfect

specimen (*ibid.*, Plate XLVIII., figs. 10-13), which Eth. fil. figured and described as *P. dubia*. He remarked that it was peculiar amongst the species of this genus for a remarkable difference in the glabella and that the pleura of the pygidium were too few. (Geol. and Pal. of Q'ld.), see also further notes on differences (N.S.W. Pal. Memoir No. 5, p. 127). Mitchell refers to it as a typical *Phillipsia* but states—"*P. stanvellensis* is so different from all foreign and other Australian species that it is not necessary to detail its relationships with them." Perhaps some doubt may be entertained as to the generic identity of both Star specimens.

‡ *Lepidodendron australe* is recorded also from Canoona (I.) and from one of the Training Wall Quarries (II.) both in the Rockhampton district, and from Cannindah, Upper Burnett district. (F.W.W. in Q.G.M. Jour. vol. 28, p. 189.)

(f) Specimen figured (refer to references below).

REFERENCES FOR RECORDS IN TABLE I.

(i.) W. Carruthers .. Quart. Jour. Geol. Soc. Lond., vol. xxviii., p. 350 (1872).
(ii.) R. E. Etheridge, Junr. "Geol. and Pal. of Q'ld. &c." Q.G.S. Pub. No. 92 (1892).
(iii.) F. Chapman .. .. Proc. Roy. Soc. Vic., vol. 18, pt. 1 (1905).
(iv.) J. Mitchell .. .. Proc. Linn. Soc. N.S.W., vol. xliii. (1918).
(v.) F. W. Whitehouse .. Q'ld. Govt. Min. Jour., April (1929).
(vi.) R. E. Etheridge, Junr. Q'ld. Geol. Surv. Museum Coll.

Notes on Table I. (Lower Star).

Out of the 32 genera listed the following (8) are recorded from the succeeding Rockhampton Series (Lower Carboniferous):—*Fenestella*, *Leptæna*, *Chonetes*, *Schizophoria*, *Rhynchonella*, *Spirifer*, *Retzia*, and *Bellerophon*. Only three identical species are recorded in both. *Phillipsia* is omitted from consideration. The comparison is, of course, unsatisfactory, and must be far from complete on account of the restrictions placed on the listing of the Rockhampton Series owing to collections from unknown horizons in the Lower to Upper Carboniferous sequence.

TABLE II.

FOSSIL FLORA, &c., RECORDED FROM THE **UPPER STAR** FORMATION.

	Drummond Range.	Silver Valley, Herberton.	Pascoe River.	Elgin Downs, Clermont.
Calamites varians	(?)			
Calamites sp.	..	..	..	x
Asterocalamites scrobiculatus Schlotheim	(?)			
Lepidodendron veltheimianum Sternbg.	x			
Lepidodendron sp. (Carb. type *fide* Walkom)	..	..	..	x
Lepidodendroid stems (Carb. type)	..	..	x	
Cyclostigma australe Feist	(?)			
Stigmaria	(?)			
Cordaites	(?)	..	x	
**Aneimites austrina* Eth. fil.	x (f)			
**Aneimites orata* McCoy	..	x		
Neuropteris (allied to *N. gigantea*)	(?)			
Equisetaceous stems	..	x		
Seeds (*Cardiocarpus*)	..	x		
Palæoniscid scales and bones	x			

Those marked (?) are recorded from the Drummond Range and localities are too indefinite to indicate from what part of the undivided Star Series they come.

* *Aneimites* beds may have to be regarded as of Neerkol age.

REFERENCES.

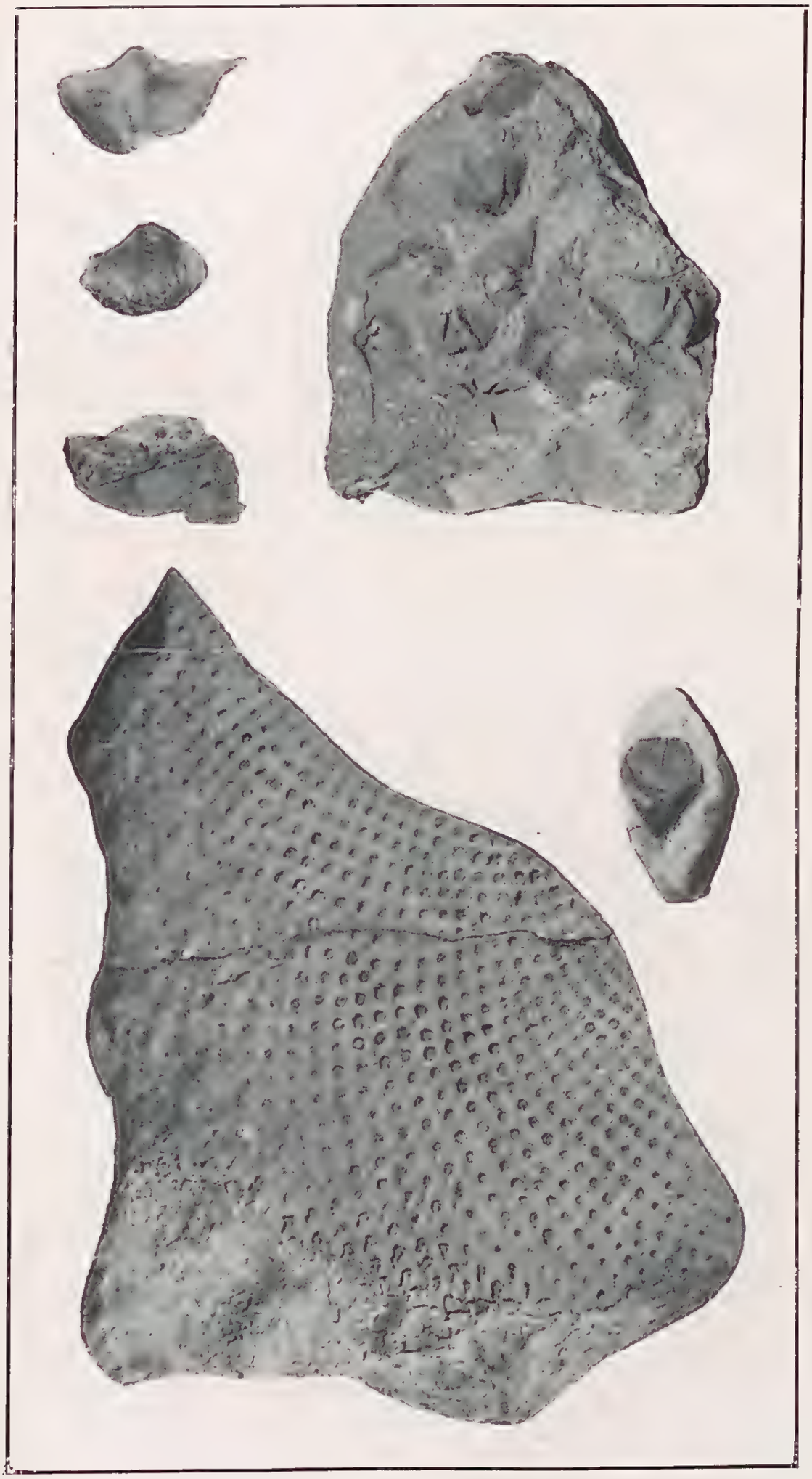
R. E. Etheridge in "Geol. and Pal. Q'ld." Q.G.S. Pub. 92 (1892).
J. Stirling in "Silver Valley Monograph."
A. B. Walkom, Q.G.M. Jour. 1924, p. 81 (for Pascoe River).

V.—ROCKHAMPTON SERIES.

The term was apparently first instituted by Daintree[36] in the following phrase:—

"The slates and limestones of Rockhampton may be taken as representative of the Lower Devonian and so called the Rockhampton Series."

Jack did not perpetuate the series and placed these beds in the Gympie Formation in the 1892 edition of the State Map. Dunstan[37] in 1916 separated the Rockhampton Series from the Gympie, placing the former as Carboniferous, i.e. synonymous with the Lower Carboniferous of Europe



FOSSILS OF THE LOWER STAR FORMATION.

Spirifer disjunctus (Mount Wyatt), *Calceola* sp. nov. (Ukalunda).
Receptaculites australis, $\frac{1}{3}$ nat. size (Mount Wyatt district).

in the sense in which it is used in Australia. This has proved to be the correct age, for there seems no dissent from the view that the series is largely the equivalent of the Burindi Series in New South Wales, the fauna and lithology of the two being in great harmony.

It is at present an unsatisfactory series in that its limits cannot be well defined, particularly its descent into what may be confidently anticipated to be a generally conformable relationship with the Upper Devonian. Upwards it is known in the Stanwell district to ascend to the Lion Creek limestone, which is placed by Whitehouse[38] on the horizon D_2 of the Avonian succession. In the Berserker Range district it apparently passes up to the Gympie Formation without angular unconformity, although the junction may be marked there by a disconformity which has not yet been observed but which was postulated by Reid and Morton[39] for the relationship of the Lion Creek Limestone and the Neerkol Series lying on it, the latter of which it is considered might be included as the lower division of a revised definition of the Gympie.

It will almost certainly be ascertained by further fieldwork that the most complete section of the Rockhampton Series will be found in the Upper Burnett region, particularly in the districts lying between Cannindah, Cania, and Mundubbera. In the first-named district there are considerable thicknesses (up to 90 ft. individually) of oolitic limestones, of later age than the *Amygdalophyllum-Lithostrotion* horizon, which are not known to be represented in the Rockhampton-Stanwell area. In the Cania district Rands has figured a section that includes some thousands of feet thick with oolitic limestones as the terminal strata, and this, as to the thickness, is somewhat in keeping with the writer's examinations in the Cannindah district, in which locality the horizon correlated with the Lion Creek limestone is the lowest oolitic limestone known.

The Rockhampton Series is herein regarded as being approximately the marine equivalent of the freshwater Upper Star Series which contains *Lepidodendron veltheimianum*, thus indicating a considerable regression of the sea in the Capricornian Geosyncline in the direction of the present coastline of Queensland towards the close of the Upper Devonian period.

In general the Rockhampton Series is characterised by considerable developments of oolitic limestones, which in many cases are markedly lenticular, banded cherts which weather beautifully into black and white bands, greenish to dark mudstones and shales, calcareous greywackes, grits, sandstones, and pebble conglomerates. Contemporary volcanics, flows, and tuffs are abundantly developed, of andesitic types to a dominant degree, but appear sporadically distributed. The oolitic limestone of Lion Creek is characterised by the occurrence of such genera of first importance as *Lithostrotion* and *Amygdalophyllum*.

In the district of Rockhampton no detailed survey has unfortunately been made. It is known, however, from various traverses and some survey work that the series is thrown into large folds, and the base has not yet been determined though it might be expected to pass down into the Devonian System in the eastern portion of the Berserker Range. The numerous limestone lenses may be signalled as seemingly identical in type and age with those described by Benson and Sussmilch in the Burindi of New South Wales, and indicate a marked degree of similarity in sedimentary conditions, during that period, for portions of New South Wales and Queensland. Those in Rockhampton itself, mostly a few feet thick, are oolitic and massed with crinoids, while the gasteropod *Loxonema* is of common occurrence. They laterally pass rapidly by gradation into calcareous grits in a distance of a few feet in many cases.

The thickness of the series is unknown, but in the environs of the city 5,000 to 6,000 ft. could probably be accounted for, and between the Kabra and Gracemere limestones the figure may reach 8,000 to 10,000 ft.* The latter estimate could only be considered most tentative, as based on a rapid traverse and with the additional qualification that the area is most intruded, if not faulted also. Indeed the Rockhampton district Upper Palæozoic rocks are amongst the most abundantly intruded in the State by masses of granites, diorites, porphyries, and dykes of dolerite and andesite. These are possibly all of late-Permian age, for they are not known to penetrate the overlying Stanwell Mesozoic coal measures.

In the Mackay-Proserpine coastal district the series as far as known is almost entirely a volcanic (andesitic) one in which several sedimentary layers, of oolitic limestone and fossiliferous sandstones, have determined its horizon.[40] This section, dipping steeply, conformably lies under a great thickness of freshwater beds ranging up to, apparently, the Middle Bowen coal measures which contain *Glossopteris*. In the Upper Burnett the Cannindah-Monto limestone belt is the thickest development recorded in the State of oolitic limestone,[41] and the writer estimates a thickness, including any foreign bands, of 400 ft. in one locality. This important limestone horizon appears entirely interbedded with a volcanic series near the township of Monto and is thrown into a large anticlinal fold.

Farther east on this anticlinal a section was recently obtained by the writer in the same district, and adds considerably to the hitherto unknown section lying above the *Amygdalophyllum-Lithostrotion* horizon. At an interval above it, not yet ascertained, a section has been traversed approximating to a thickness of 1,750 ft. The lower half includes three distinct oolitic limestone horizons interbedded with calcareous grits, sandstones, conglomerates, and greywackes, while the upper half is devoid of limestone and consists largely of dark-blue

* This section, however, may possibly range down to and include in part Upper Devonian beds.

mudstones, with some marine fossils and pebbly conglomerates. The section is—

		Feet.
	Mudstones with *Schizophoria* sp. nov., &c.	100
	Grits, mudstones, &c.	625
(*a*)	**Limestone** with *Palæosmilia*	90
	Conglomerates and grits	300
(*b*)	**Limestone**	40
	Grits and conglomerates	130
(*c*)	Grits and conglomerates with **limestone** bands and lenses ..	200
	Grits and fine sandstones	240
	Strike N. 30° E., Dip E. 30° S., Angle 40° .. .. (*Estimated*)	1,725

GEOLOGICAL SECTION BY J. H. REID, PORS. 37 AND 38, PH. CANNINDAH, THREE MILES S.W. OF KALPOWAR.

The fossil collection in the top mudstones has been listed by Dr. Whitehouse as—

Schizophoria sp. nov.
(= "*Orthis resupinata*" Dun and Benson, *non* Martin.)
Actinoconchus cf. *planosulcatus* (Phill.).
Spirifer spp. nov. (two species).

From the top limestone (*a*)—

Palæosmilia aff. *retiformis* (Eth. fil.).
*Gen. et sp. nov. (a new genus of corals of unknown affinities).

West of the Stanthorpe granite area, in the districts generally between Leyburn and Texas, Ball[12] has described Carboniferous rocks consisting of manganiferous and jasperised slates, shale, and schistose slate which are associated in the field with limestone at Texas and Gore. From the Texas limestone Mr. Ball informs me that he has collected *Lithostrotion*, which has been confirmed by Dr. Whitehouse. These Carboniferous rocks are possibly interfolded with Middle to Upper Devonians, for Dr. Bryan has lately informed me that *Heliolites* has been collected at Gore, and the rocks in the area generally are described as extremely folded and crushed.

As far as known the distribution of marine beds of Rockhampton age is confined to the coastal region lying to the *east* of the Great Syncline, between Proserpine and the New South Wales border. In this area, according to the views advanced herein, their outcrops may be found to be widely separated by the combined effects of great folding and subsequent erosion *plus* Mesozoic sedimentation on a sequence ranging from, possibly, Middle Devonian to Permo-Carboniferous, in which they have been strongly folded in late-Permian time, warped as in the Texas and Cannindah districts, and very much faulted.

* This form has been almost simultaneously found in the limestones above the *Amygdalophyllum* horizon at Mundubbera, by a Brisbane University geological party (*fide* Whitehouse).

We have indeed evidence of many Lower Carboniferous occurrences throughout this area, and for the rest of Queensland it is suggested that freshwater equivalents only exist.

The position regarding the faunal records of the Rockhampton Series in the type district is very unsatisfactory owing to the fact that, in most cases, localities are insufficiently definite and horizons are thus indistinguishable between at least two conformably related series (Rockhampton and Gympie) which, it is thought, range from Lower to Upper Carboniferous and probably have many forms in common but whose boundaries have not even been mapped.

It was, until 1916, considered as forming part of the Gympie Formation, but it would be now unsafe to accept Jack's recorded fossil localities (*vide* p. 92, Geol. and Pal. of Q'ld.), or to draw deductions as to horizons, for the reason that they are mixed up or unknown. What could be more regrettable than that de Vis' valuable collection, with several zonal diagnostic forms, should be grouped under "Rockhampton District"? The following is the writer's present conclusions as to the status of Jack's localities after personal investigation of the Stanwell district localities of the late Jas. Smith (R. L. Jack's collector). (R. = Rockhampton; G = revised Gympie Formation.)

No. 1. Lilymere Limestone	R.
No. 2. Lake's Creek and Training Wall Quarries	R. and G. mixed
No. 3. Blackfellow's Diggings	G.
No. 4. Stony Creek (boulders) and Crow's Nest	G. mostly; R (?)
No. 5. Encrinite Creek	G.
No. 6. Fenestella Hill	G.
No. 7. Athelstane Range	R.
No. 8. Don River	Prob. G.
No. 9. "Rockhampton District" (de Vis' Collection) ..	R. and G.

It seems only safe to use (1) and (7) for compiling faunal lists, but No. 9 contains mostly lower forms, and in these, three ammonoids that Dr. Whitehouse[43] regards as indicating the base of the Carboniferous have been included. These notes will explain the paucity of forms listed in the type area. With regard to No. 4 locality, Stony Creek and Crow's Nest, the most prolific collection of Stanwell marine fossils has come from Lamond's Farm, Stony Creek. Investigation of this locality by the writer showed that it has no definite stratigraphical status, for it occurs in an area of Mesozoic coal measures (for record purposes it once existed on por. 4, ph. of Stanwell), and the fossils have undoubtedly come from a large bank of fossiliferous boulders in the creek from which specimens may be still collected. The creek above the Mesozoic measures drains an area of some 30 square miles which include the Crow's Nest trilobite beds, thought to be equivalent to the Neerkol Series. These collections have been omitted from both faunal lists, but can probably be regarded as representing Gympie, possibly Rockhampton also, but apparently not any of the marine Bowen (Permo-Carboniferous) Series.

Lion Creek Disconformity.—The case for this was stated by Reid and Morton as follows:—

"A strong case for a disconformity between the Lion Creek Limestone and the Stanwell Marine Series can be made out. The strong lithological break between limestone and conglomerate evidently marks a time break accompanied by slight crustal movement and in the beds above the conglomerate there is apparently a tremendously increased development of *Fenestella* and *Productus*, genera which appear rather rare in the Rockhampton Series. Particularly is this so in the case of *Productus* for Jack has cited only one species from the Rockhampton district, and that is one which appears to resemble a common form at Lake's Creek, in beds which are now generally thought to be on a considerably higher horizon." (Q'ld. Govt. Min. Journ. 1928, p. 386.)

To the above might be added that *Spirifer* aff. *striatus*, a characteristic species of the Rockhampton Series, is known to ascend to the Lion Creek (D_2) horizon but not higher there and that in the Neerkol series *S.* aff. *mosquensis* is present; also that *Protoretepora* is present in the low *Pustula* horizon and not recorded in the Rockhampton beds. Whitehouse opposed this disconformity, quoting a list of the fauna from near the base of the series (the *Pustula* bed) and commented as follows (*ibid.* p. 441):—

"It is a new sub-fauna of our Carboniferous sequence and indicates the horizon to be in the lowest part of the Upper Carboniferous or the top of the Lower Carboniferous. This agrees with its position immediately above the *Amygdalophyllum* limestone of Lion Creek, the fauna of which, as I have suggested elsewhere, may be correlated with zone D_2 in the uppermost part of the Lower Carboniferous"

and—

"Both the Rockhampton Series and the Burindi Series include beds above and below the *Amygdalophyllum* limestones."

The point was of some importance regarding the case for a transition series in so far as the suggested correlation of the upper portion of the Neerkol beds with the lower portion of the alleged Bowen beds of Lake's Creek was concerned. One view tended to drag down the horizon of the Neerkol series in the Carboniferous, the other tended to establish it as starting at an indefinitely later stage than the Lion Creek horizon of the Rockhampton Series and somewhere in the lower portion of the Upper Carboniferous.

The writer has presented a somewhat detailed section in this report (p. 32) showing a minimum of 1,725 ft. of strata in the Cannindah district which are stratigraphically above the Lion Creek equivalent there, and seem positively on the limited palæontological evidence and the typical Rockhampton rocks to be below the *Pustula* horizon near the base of the Neerkol beds. These are not represented at Lion Creek above the limestone horizon. We may thus agree with the latter statement that both the Rockhampton and Burindi Series include beds above and below the *Amygdalophyllum* limestone, but it seems on the above evidence that the Neerkol marine sequence is entirely younger than Lower Carboniferous and thus favours a closer *rapprochement* in age with the generally accepted age of Upper Carboniferous for Lake's Creek and equivalents. The greater the time period involved in this disconformity the stronger becomes the case for uniting the grits and bryozoan mudstones of Lake's Creek and the upper portion of the Neerkol Series which, to Morton and the writer, appear identical.

TABLE III.

FAUNA AND PLANT RECORDS (RESTRICTED) OF THE **ROCKHAMPTON** SERIES.

	Refs.	Rockhampton.	Lion Creek Limestone.	Cannindah, Upper Burnett.	Cania Town and Beatty's Creek.	Other Localities.
Cyathaxonia (?) sp.	(vi.)	..	..	..	x	
Pleurophyllum spp. indet.	(vi.)	..	..	..	x	
Lophophyllum (?) *corniculum* de Kon	(vi.)	..	..	..	x	
Cionodendron (?) sp.	(iv.)	..	..	x		
Amygdalophyllum inopinatum Eth. fil.	(ii.) (iv.)	..	x (f)	x		
Lithostrotion arundineum Eth. fil.	(ii.) (v.)	..	x (f)			
Lithostrotion columnare Eth. fil.	(ii.) (v.)	..	x (f)			
Lithostrotion stanvellense Eth. fil.	(ii.) (iv.)	..	x (f)	x cf.	..	sp.
Michelinia sp.	(ii.) (v.)	..	x			
Syringopora syrinx Eth. fil.	(ii.) (iv.)	..	x (f)	x		
Syringopora sp. nov.	(v.)	..	x			Texas.
Petalaxis sp.	(v.)	..	x			
Palæosmilia retiformis Eth. fil. ms.	(v.)	..	x			
Archimedes sp.	(viii.)	..	..	..	..	x
Evactinopora sp.	(viii.)	..	..	..	..	x
Fenestella sp.	(vi.)	..	..	..	x	
Myriolithes (?) *queenslandensis* Eth. fil.	(i.)	x				Mundubbera.
Geinitzella (?) sp.	(vi.)	..	..	..	x	
Leptæna analoga Phill.	(F.W.W.) (vi.)	..	x	..	x cf.	
Orthotetes sp. nov.	(vi.)	..	..	..	x	
Chonetes cracowensis Eth.	(i.)	x				
Chonetes sp. ind.	(i.) (vi.)	x (f)	..	..	sp.	
Productus sp. ind.	(vi.)	..	..	..	x	
Schizophoria resupinata (Martin)	(i.) (vi.)	x	..	..	sp.	
Rhynchonella sp. ind.	(i.)	..	..	..	x	
Spirifer aff. *mosquensis* (Fischer)	(vi.)	..	..	..	x	
Spirifer cf. *pinguis* Sby.	(vi.)	..	..	..	x	
Spirifer davidis Dun	(vi.)	..	..	..	x	
Spirifer aff. *striatus* Sby.	(vi.)	..	..	..	x	
Spirifer (cf. "*S. striatus*" of Burindi)	(F.W.W.) (iv.)	..	x	x	..	x
Martinia (?) *productoides* Eth. fil.	(i.)	..	..	..	x (f)	
Retzia (?) *lilymerensis* Eth. fil.	(i.)	x				St. Helens.
Edmondia cf. *sulcata* Phill.	(vi.)	..	..	..	x	
Parallelodon sp. nov.	(vi.)	..	..	..	x	
Mourlonia strzeleckiana Morris	(i.) (vi.)	x	..	..	sp.	
Bellerophon sp. nov.	(vi.)	..	..	..	x	
Straparollus davidis Dun & Benson	(vi.)	..	..	sp. ?	x	
Loxonema	(i.)	x				
Eumorphoceras (?)	(iii.)	..	..	..	..	x
Pseudarietites (?) *ammonitiformis* Eth. fil. m.s.	(i.) (v.)	x (f)				Upper Burnett (Dawes Range).
Pseudarietites dubius Eth. fil. m.s.	(i.) (v.)	x (f)				
Protocanites planorbiformis Eth. fil. m.s.	(i.) (v.)	x (f)				
Phillipsia sp. nov.	(vi.)	..	..	..	x	
Phillipsia rockhamptonensis Mitchell	(vii.)					
Lepidodendron sp.	(i.)	x				
Calamites	(i.)	x				
Girvanella	(ii.)	..	(?)			

x Indicates the particular species, but sp. in locality column indicates the genus only (species not determined). (f) Specimen figured, refer to references below.

References for Records in Table III.

(i.) R. E. Etheridge, Junr., in "Geol. and Pal. of Q'ld., &c.," Q.G.S. Pub. No. 92 (1892).
(ii.) R. E. Etheridge, Junr., Q.G.S. Pub. No. 154 (G.S. Bull. 12), (1900).
(iii.) F. W. Whitehouse, Proc. Roy. Soc. Q'ld. 1927, p. xi. (1927).
(iv.) F. W. Whitehouse, Q.G.M. Jour. 1927, p. 189 (1927).
(v.) F. W. Whitehouse, MS. "Notes on Geology of Rockhampton District."
(vi.) F. W. Whitehouse, MS. Cania fossils collected by C. C. Morton (1928).
(vii.) J. Mitchell, Proc. N.S.W. Linn. Soc., vol. xliii. (1918).
(viii.) F. W. Whitehouse, Proc. Roy. Soc. Q'ld. (1929).

Notes on Table III. (Rockhampton Series).

The limits of this series have not been fixed, but in the type district the Lion Creek limestone has been taken as the upward limit, a disconformity there dividing it from what is considered to be an Upper Carboniferous sequence (Neerkol Series). This uncertainty of limits and the restrictions already enumerated make comment of these lists rather unsatisfactory and of a strictly tentative nature. Of the 33 genera listed, 8 are recorded in the Lower Star Series and the following species have ascended therefrom :—*Schizophoria resupinata*, *Chonetes cracowensis*, and *Leptæna analoga*. The corals have shown a marked change in that *Pachypora* and *Calceola* are replaced by the typical Carboniferous *Lithostrotion*, *Michelinia*, *Cyathaxonia* (?), &c. In the *Spirifers*, *S. disjuncta* has given place to dominant numbers of the *S. striatus* group and *Spirifer davidis* of the Burindi has appeared. If Etheridge's determination remains valid we have the first appearance of the common Mid-Bowen gasteropod *Mourlonia strzeleckiana* from the Lilymere limestone, Rockhampton.

VI.—THE EVIDENCE FOR A LOWER CARBONIFEROUS-PERMO-CARBONIFEROUS TRANSITION SERIES.

One of the main purposes of this paper is to put the case for a more or less complete marine succession in Queensland, from the Rockhampton Series to the Lower Bowen, with evidence of faunal transition, though the view seems to have been regarded as established that in Eastern Australia there was a clear faunal break. This has been established on New South Wales evidence, apparently as between the faunal relationship of the Carboniferous and Permo-Carboniferous beds of the Hunter River district. The reason now seems obvious—since the grounds for belief in an intervening structural break there appear to have disappeared—the interposition of the Kuttung terrestrial deposits and it appears safe to anticipate that they do not exist as such in South-eastern Queensland. Two alternatives appear possible in that portion of Queensland—a Kuttung cycle of erosion or a period of marine sedimentation. The former does not appear to warrant consideration in view of the geological sections in the Rockhampton and Mackay districts. It is suggested that, in part, the work of Reid and Morton in 1928, in the Stanwell and Rockhampton districts, advanced sufficient grounds to warrant the statement that a more or less continuous sequence of sediments was laid down in a prevailingly shallow epeiric sea during the Kuttung period. It is considered that the sea during that period extended not much northwards of Broadsound, and occupied a relatively narrow coastal strip of present-day Queensland down to the New South Wales boundary. A strongly indicated similarity of sedimentary and volcanic deposits in New England areas of New South Wales, e.g. Drake and Kempsey, &c., suggests that this marine sedimentation extended down to the Kuttung strand, wherever that may have been (was it not the north-eastern coast of a partially reduced continental surface resulting from geographically limited late-Devonian orogeny (?) and it is tentatively suggested that the described Permo-Carboniferous deposits of Drake, Boorook, Vegetable Creek, Kempsey, &c., may in part represent beds of this transitional faunal series and in part Lower Marine. If such should prove to be the case, the typical terrestrial and glacial deposits of the Kuttung would not be expected to occur beyond

that strand line towards Queensland *and would probably be replaced by marine equivalents with elements of the Burindi and Lower Marine faunas.*

The first suggestions of the possibility of a marine transition series, and corresponding fauna, would seem to have come from New South Wales. Andrews[44] in 1908 expressed, or at least implied, this for Drake and Warwick areas, in part, and Dun[45] also noted there a mingling of Lower Marine with slightly older types. Osborne[46] in dealing with the late-Palæozoic folding in the Hunter River commented on the bearing the age of the Drake slates would have on its age—

"the palæontological evidence seeming to indicate a facies transitional between Kuttung and Lower Marine or between Burindi and Lower Marine."

Dun's statements in 1911[47] are of very great interest in view of more recent Queensland data on the subject of an Upper Carboniferous transition fauna. He indicated then that the Permo-Carboniferous sediments in Northern New England may be in part correlated with the Gympie beds, and that if a direct succession existed it probably occurred in the areas to the north of the type district of Maitland. The same authority[48] in 1924 indicated in the basal Permo-Carboniferous beds of Gosforth a possible relationship with the Burindi fauna in the presence of *Seminula* and a *Spirifera* "of a distinctly transitional type."

The fossils from Jump-up Hill, Drake, as determined by Dun,[49] include three Carboniferous types, *Spirifer* cf. *lata*, *Reticularia* cf. *lineata*, and *Fenestellida* in association with Permo-Carboniferous forms including the typical Lower Bowen "*Productus*" *subquadratus* (Morr.). From the Kempsey beds[50] comes a similar association with four Carboniferous forms—*Phyllopora* (cf. *Retepora* (?) *laxa*), *Productus* cf. *undatus*, *P. semireticulatus* (?), *Cladochonus tenuicollis*.

The Vegetable Creek (N.S.W.) area is one of particular interest in regard to the whole problem. The strata there, before any fossils were found, were regarded by David[51] as possibly Siluro-Devonian (a tribute surely to their appearance of age and alteration). Later (1893) he found a form closely allied to *Protoretepora ampla*[52] (the genus starts well down in the Carboniferous sequence at Neerkol) and a small species of *Productus* (a very small one has been collected from Lake's Creek and Neerkol) and referred them to the Gympie horizon of Queensland. Pittman[53] traced these Gympie (Carboniferous) beds (*sic*) from Southern Queensland to Ashford. Later, Carne,[54] at David's fossil locality, and also at Rocky Creek, found a "Permo-Carboniferous" collection of fossils and they were then placed in the Lower Marine. On the above evidence, particularly Pittman's statement "traced by me without any break in their continuity," the writer concludes that David's reference of 1893 was likely to be the more correct, but that probably the Lower and Upper Carboniferous sequence of Queensland occurs there as both are held to be represented in the adjoining Texas district. Supporting David's reference with regard to the type Gympie area is the occurrence of impure limestones and calcareous mudstones[55]

(the Gympie black limestone facies is never met with in the marine series of the Hunter and Bowen Rivers) and *Stenopora* cf. *gimpiensis* (not recorded in either the Hunter River or Bowen Coalfield). Out of twenty fossils recorded by Dun and Carne from Vegetable Creek, nine similar or closely related forms come from Gympie alone. A common Burindi genus (*Loxonema*) is doubtfully recorded at Vegetable Creek. David's following statement[56] as to lithology also supports a claim to the strongest comparison with the Neerkol Series and to some extent with Gympie Goldfield and Lake's Creek beds as follows:—

"olive-green clay shales passing into dark blue and black claystone, . . . siliceous grit and quartzite."

The data mentioned suggest good grounds for a provisional correlation of Vegetable Creek and Gympie Goldfield, in part.

To turn to Queensland: The Stanwell-Rockhampton section shows a conformably bedded and folded section ranging upwards from the Rockhampton Series to the Lion Creek limestone. Lying on this with a marked disconformity, in which is involved a sedimentary non-sequence of at least a minimum of about 1,750 ft., as evidenced by the Cannindah section described previously herein, lies a very uniform series 4,500 ft. (?) thick of hard, dark-coloured (bluish-black) to green mudstones or shales and light-coloured gritty rocks, recently described as the Stanwell Marine Series, but, to avoid confusion, now referred to as the Neerkol Series. In the lowest mudstones of this series, probably only several hundred feet above the limestone, is a rather prolific fossil horizon. The forms from it have been named by Whitehouse, who refers to the collection as a new sub-fauna of the Carboniferous sequence, and indicates the horizon to be the lowest part of the Upper or the top of the Lower Carboniferous. The dominant form in this bed is probably a productid, *Pustula*, which is apparently the *Productus brachythærus* Sby. (?) of Etheridge for Stanwell (see pl. 13, fig. 5, "Geol. and Pal. of Q'ld.") This horizon invests the series with the greatest interest in view of Schuchert's[57] recent references to the lack of knowledge of Upper Carboniferous marine faunas in Australia. This moderately low Carboniferous horizon is itself doubly interesting because of the appearance of one or perhaps two genera that have been regarded as characteristically Permo-Carboniferous heretofore. A single specimen at least of *Protoretepora* (probably allied to *P. ampla*) occurs in the collection, as well as rather numerous *Stenopora* (?). This is evidently the lowest horizon for *Protoretepora* known in Eastern Australia. Some distance above this, in a mid-section of the series, is an especially rich fenestellid zone with abundant *Protoretepora*. The section above this has a very striking lithological resemblance to a section below the Lake's Creek Quarry fossil bed and, although that horizon has not been identified in the Stanwell-Neerkol section, Reid and Morton tentatively correlated the two on lithological, structural, and some palæontological grounds, while agreeing that the Lake's Creek Quarry fauna must undoubtedly be on a considerably higher horizon in the transition series

than the Neerkol *Pustula* horizon. In the Queensland Geological Survey Museum collections are specimens of "*Productus*" *subquadratus* (Lake's Creek form) and *Aviculopecten squamuliferus* from the Stanwell area. While they are from now unidentifiable horizons, they are evidently a further correlative link between some portion of the Lake's Creek and Neerkol sections. The marine series terminates after several intercalations of andesitic lavas, with an overlying series of heavy boulder conglomerates many hundreds of feet thick. This indicates crustal movement and probable disconformity, and this break could cover possibly the characteristic fossil horizon of Lake's Creek, Gympie Goldfield, &c., which does not appear to occur in the Neerkol section.

Whitehouse[38] has opposed the suggested correlation of any portion of the Lake's Creek beds with the Neerkol Series, believing the former to be of basal Middle Bowen age, and obviously the case for correlation collapses if such an age can be proved for it.

Apart from any question of correlation of portion of the Lake's Creek beds with portion of the Neerkol Series on the grounds just adduced, the writer, on evidence quite internal to Lake's Creek, is not disposed to admit without contest the view that the Lake's Creek Quarry horizon can be the equivalent of that of any horizon of the Bowen Series in the Great Syncline (with the possible exception of the Yatton limestone horizon, about the exact position of which much doubt is now felt). This attitude is based collectively on the following evidence:—(1) Extreme differences in lithology; (2) the *average* diminutive fauna of Lake's Creek, which it is considered is not even paralleled in any Lower Bowen horizons observed; (3) the facies of the fauna, allied to the relative abundance of a very small *Productus* at Lake's Creek, which it is held has not been found in any horizons of the Bowen Series in the Great Syncline; (4) the marked faunal differences between Lake's Creek on the one hand, as detailed later, and the Bowen beds ranging up from the Dilly and Mount Britton horizons of the Lower Bowen to the Collinsville stage of the Middle Bowen, on the other; and (5) because the stratigraphical interpretations mentioned herein most strongly indicate they are below the Lower Bowen volcanics of Stanwell.

The heavy boulder-conglomerates form the base of the Dinner Creek Series (3,200 ft. ?), and as they have been derived partly from the whitish grits of the Neerkol Series, a considerable break in sedimentation is evinced. They continue rather uniformly through a series of *Glossopteris* shale beds with numerous volcanic flows (andesites and rhyolites), on which a 5,500-ft. section of Lower Bowen volcanics rests conformably. The whole section is considerably folded, and on the planed-down edges lie the unconformable Stanwell coal measures (Mesozoic).

In the next synclinal eastwards are the Lake's Creek beds overlying the cherts and andesites of the Lower Carboniferous Series at an unmeasured interval above. The country is not mapped, but three

traverses have been made to endeavour to assure evidence of relationships between the Rockhampton Series and the Lake's Creek fossil beds. These indicate a conformity of strike and dip between the two, and there seem no grounds for supposing other than that a general sequence of angularly conformable sedimentation exists, though the probability of non-sequence or faulting in the section could not be denied. In these traverses, for instance, no trace was found of the important horizon of Lion Creek limestone.

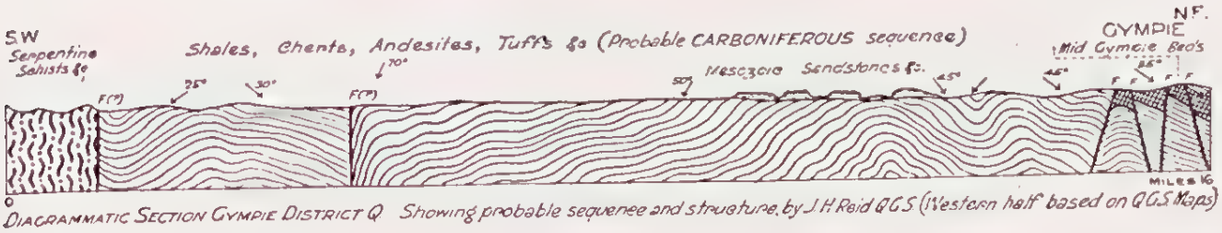
Whitehouse[59] considers the Lake's Creek Quarry beds as of basal "*Middle Bowen*" age, resting unconformably on the Rockhampton Series. As to this interpretation of their stratigraphical relationships, it is, as stated above, entirely at variance with the conclusions of Reid and Morton, and they cannot accept it. The Quarry beds, for example, dip and strike in the same general direction and degree as numerous readings of the Rockhampton Series in the surrounding country. These show that the latter have many gently dipping areas in the surrounding areas, angles as low as 10° to 25° having been recorded over considerable tracts. If the former are of Middle Bowen age, how may be accounted the absence beneath them of the Lower Bowen Series, for no thicker section of them is known in Queensland than that which exists in the neighbouring syncline of Stanwell at a distance of 16 miles from Lake's Creek? It is estimated there to be 8,700 ft. thick, including the Dinner Creek *Glossopteris* beds, and apparently the series extends unbroken for 200 miles north-west to the Bowen River. To suggest their absence by great faulting or non-sequence would seem inadmissible, but at least leaves it incumbent on anyone who might still advocate a Middle Bowen horizon for Lake's Creek Quarry to satisfactorily explain the absence of the Lower Bowen Series.

Of the Lake's Creek Quarry fauna, quoted by Whitehouse,[60] *Monilopora nicholsoni*, *Taniotharus subquadratus* (Lake's Creek type), and *Anidanthus* sp. cannot now be considered by the writer as present in any Middle Bowen horizons of the Great Syncline in Queensland or its equivalents in the Hunter River (N.S.W.). Further, lower forms have been determined from the Quarry, such as *Productus* (*muricatus* group), by Dun, and as *Urania Koninckii*, by Etheridge, though the latter may not be from that exact horizon, the locality being registered as Lake's Creek.

Gympie Goldfield has a fauna closely tied to Lake's Creek and Condamine Block, as shown by Whitehouse, with, in many respects, a characteristic Permo-Carboniferous assemblage. In it there is a commingling of lower forms (from the Middle Gympie horizon of Dunstan), determined by Etheridge as follows:—*Polypora* (*?*) *smithii*, *Rhombopora laxa*, *Stenopora gimpiensis*, and *Leptæna analoga*,* the first two species of which are recorded from the Neerkol Series by the same authority. The "Middle Gympie" Series, which is generally

* See footnote (*a*), fossil table IV., as to probable mistaken identity.

accepted as equivalent to that of Lake's Creek, passes down to a very thick series of shales, mudstones. cherts, and andesites, the upper portion of which has been mapped by Dunstan[61] as Lower Gympie (stated to be probably equivalent to the Rockhampton Series), and considered by him to be probably unconformable with the Middle Gympie.[62] The section from the "Middle Gympie" downwards, traversed by the writer, is a very thick one, and probably includes equivalents of much of the Neerkol Series, as well as the Rockhampton Series. No grounds have yet been advanced for an unconformity, and such appears improbable, for the black fœtid limestones of the "Lower" Gympie are identical in type with those of the "Middle Gympie," and, moreover, the lower beds have the same general direction of strike and dip, for a distance



DIAGRAMMATIC SECTION GYMPIE DISTRICT Q. Showing probable sequence and structure, by J. H. Reid Q.G.S. (Western half based on Q.G.S. Maps)

normal to the strike of at least 4 miles as the "Middle Gympie" beds, allowing for very great disturbance and erratic dips, including reversals, in the vicinity of the great Laing slide, which forms a junction between "Middle" and "Lower" Gympie in places. This, in conjunction with evidence of angularly conformable relations from Lower Carboniferous up to either Upper Carboniferous or Permo-Carboniferous at Lake's Creek, Stanwell, and Mackay (St. Helens), can be interpreted as strongly indicating probable conformity at Gympie, a relationship that the writer, after a recent traverse, fully expects to be established by detailed work. The age of the lower beds, however, can only be assumed to be Lower Carboniferous until definite fossil proof is forthcoming. The writer supports Dunstan's tentative correlation of "Lower" Gympie (in part) with the Rockhampton Series on the common presence of a great thickness of shales with intercalated cherts, andesites, and tuffs, but the very typical oolitic limestones appear from a rapid examination to be conspicuously absent. There is certainly no evidence of Lower Permo-Carboniferous beds being present. The succession upwards from the lowest "Upper" Gympie shales is interrupted by a fault mapped by Ball[63] throwing them against an older unconformable phyllitic series. Thus a probably important upward sequence has been lost, which might have assisted in determining more easily the stratigraphical status of the Gympie auriferous series, but it is not possible at present to correlate with other sections the thickness of possibly 1,000 ft. to 1,500 ft. of "Upper" Gympie shales which have proved utterly devoid of organic remains so far.

The case for the establishment of an Upper Carboniferous transition series in Queensland rests mainly on the Gympie, Lake's Creek, and Stanwell-Neerkol areas. While the characteristic horizons of the *Monilopora* zone have not been found in the Neerkol Series, nor those

of the *Pustula* zone at Lake's Creek and Gympie, they are, nevertheless, tied to one or the other, to some extent, palæontologically, notably with *Protoretepora, Rhombopora laxa, Polypora smithii,* and, provisionally, *Aviculopecten squamuliferus, Productus subquadratus* (Lake's Creek type), and possibly *Stenopora.* The related fossil forms would probably be much more numerous were it not for the generally unfossiliferous character of the Upper Carboniferous sequence, if we exclude occasional narrow but prolific fossil beds (Lake's Creek is unique), as well as the fact that the Neerkol Series has not yet been fully explored for fossils occurring *in situ,* as distinct from considerable collections made from creek boulders.

The fauna of Gympie, Lake's Creek, and Neerkol is of a comparative dwarf type on an *average,* compared to that of the Lower and Middle Bowen. Certain large forms as *Spirifers,* a large *Aviculopecten,* and the very big "*Productus subquadratus*" (Lake's Creek type) occur in either of the two former beds, but are completely overshadowed numerically by dwarf forms. It is held in many quarters, particularly in New South Wales, that the Lower Carboniferous fauna is, on the whole, a depauperate one compared to that of the Permo-Carboniferous. If now a comparison is made of the Gympie and Lake's Creek collections with those from the Lower Bowen at Springsure and Craeow, or with those from the Lower Marine at Harper's Hill and Farley (N.S.W.), it is held that collectively the Gympie and Lake's Creek fauna is a dwarf group relatively, thus conforming better by its size to a time relationship with the Carboniferous pauperitic fauna than do the generously developed forms, considered in groups, of the Permo-Carboniferous. Certain species appear, on the records, to be identical in both series, and thus may have enlarged by mutation between the Carboniferous and the Permian of the Middle Bowen.

In stratigraphical relationships the Neerkol Series is the best known and gives a broken succession from the typical Lower Carboniferous up to the Lower Bowen *Glossopteris* beds with evidence of several important non-sequences, notably at the base of the Dinner Creek boulder conglomerates and the top of the Lion Creek limestone. In the Lake's Creek district there is field evidence of a more or less incomplete sequence of angularly conformable beds, from a lower series upwards, with many Permo-Carboniferous species in its highest section (in the Quarry horizon), while the same applies to Gympie. In the two latter localities the upward succession is considered to be interrupted by erosion and faulting, respectively.

Two of the three areas are far apart, and all lie in a region that has subsequently been strongly folded, faulted, and eroded, and considerably covered by later unconformable sediments. Non-sequences in the Carboniferous succession appear only too evident. Is it surprising then that the links in the chain are not as complete as could be desired? It is for that reason and the lack of detailed geological data that a problem has arisen on which differing opinions have been enunciated. The conclusion seems irresistible when the fragments are pieced together that

an Upper Carboniferous marine sequence existed throughout South-eastern Queensland, and that during that period, probably under the influence of frigid climatic conditions (dropped boulders at Silverspur and Gympie), marked evolutionary changes occurred in the fauna introducing the Permo-Carboniferous forms beginning probably with *Protoretepora*, and becoming, towards the upper terminal strata, more replete with its characteristic *Spiriferidæ, pelecypoda*, &c., while the older forms dwindled to gradual extinction. It seems on the Stanwell district section that the genesis of the *Glossopteris* flora must have closely synchronised with that of the later forms, and that both preceded those tremendous outpourings of lava of the Lower Bowen and, to a less extent, of the Lower Marine (N.S.W.).

Sections in New South Wales that may have a particular bearing on the question of a transition series in Eastern Australia are those of the Macleay and Manning Rivers. These beds as described by Woolnough[178] fit Gympie in many points—

"slates—black in colour and intensely hard . . . greenish tuff with *Pachydomus* . . glacial beds do not appear to be basal";

and, further, the statement—

"We may tentatively assume as a working hypothesis that the Gympie Series of the Queensland geologists includes the sub-glacial portions of the Manning and Macleay beds."

Rather striking also is—

"a massive bed of greenish tuff which contains abundant casts of *Pachydomus* which Dun recognises as being very similar to a form occurring in the Gympie Series at Gympie."

The great fossiliferous horizon from which the bulk of Gympie fossils has come is a greenish sandstone and tuff, in which the fossils are casts in a chlorite-green matrix.

(Horizon 1.F. Gympie Geological Map 1911, Q.G.S. Pub. 221B.)

Woolnough considers the glacials under the Parabel &c. limestone [Carne and Jones record *Eurydesma* and *Pecten* in this] to be the Lochinvar beds of the Hunter basal section. Both sections of these Lochinvar (?) beds are underlain by *great or immense thicknesses of conformably bedded tuffs, slates*, &c. What are these if not the Upper Carboniferous sequence? It is in them, in the Manning River section, that the Gympie-like *Pachydomus* and green bed appear. As the writer urges that the preponderating weight of evidence in Queensland supports Gympie *below* the Lower Bowen it may be that Woolnough's nineteen-year-old working hypothesis has very great probabilities of substantiation. The writer would especially emphasise Woolnough's 1911 statement:—

"The correlation of the *Lepidodendron* beds with those containing *Pachydomus* is a work of first-rate importance in Australian stratigraphy."[179]

It appears urgently wanted for elucidating succession and palæontological problems of both States.

Bearing on the question of tectonics as related to the possibility of transition it would, perhaps, on Queensland evidence, be reasonable to submit to New South Wales geologists the query—"Are not the Wards River *Glossopteris* beds of the Gloucester district [see Sussmilch, N.S.W. Roy. Soc. Journ. 1921] as old as, or *older* than, any Lower Marine of the Hunter?" Sussmilch on this section has come to the same conclusion as the writer has in Queensland (from Rockhampton to Mackay) as to the common folding of Carboniferous and Permo-Carboniferous. It is suggested that if we substitute Kuttung for Neerkol we have the possibility of the same approximate time sections at Gloucester and Dinner Creek, Stanwell, and in both cases Carboniferous and Permo-Carboniferous are angularly conformable. The latter beds have an undescribed species of *Glossopteris* which has right-angled nervation that the writer has never seen in forms from later Permo-Carboniferous beds in Queensland, and it is considered on all sides that Dinner Creek is the lowest horizon in Queensland for *Glossopteris*. *G. rectinervis* comes from the Wards River beds, although it is not thought that it is necessarily the same species.

The following Carboniferous forms are recorded or have been determined at various localities in Queensland and New England (N.S.W.), in association with certain Permo-Carboniferous forms:—

> *Hyalostelia, Cladochonus tenuicollis, Penniretepora grandis, Fenestellidæ, Retepora (?) laxa, Rhombopora laxa, Poteriocrinus crassus (?), Leptæna analoga, Productus semireticulatus* (Martin ?) *P.* cf. *undatus, P.* (*muricatus* group), *Pustula* sp. nov., *Spirifer* cf. *lata, S.* aff. *mosquensis, Reticularia* cf. *lineata, Macrocheilus (?), Loxonema (?).* Also *Seminula* sp. nov. in the Hunter River basal beds of the Lower Marine.

Apropos of this attempt to state the case for a transition series in Queensland, which it is thought probably continues into Northern New South Wales, wherever terrestrial Kuttung deposits do not occur, an interesting and apparently parallel case may exist in the Kimberley region of Western Australia. Blatchford[64] (1927) has shown the division of the Carboniferous into a Lower and Upper Series, the latter of which it is stated may pass up into the Permo-Carboniferous. The Lower, in the few forms listed, has no representatives of the Eastern Australian Permo-Carboniferous, but the Upper has, in four distinct horizons at least, viz., Luluigui (top, middle, and indefinite) and Selection Homestead C44, a commingling of Eastern Australian Permo-Carboniferous and Lower Carboniferous forms.[65] At the first-named horizon the association of *Strophalosia clarkei* with *Schizophoria resupinata* appears rather unexpected on Queensland evidence, for the former is dominantly a Middle Bowen species, though it ranges down to the Lower Bowen at Dilly. There is strangely enough a record by Dunstan[66] of the two occurring together at Collaroy, north-west of Broadsound, in beds described by him as Gympie under the old classification, so that it seems not impossible that further extended ranges for the two species may be satisfactorily established in Queensland by future work. An added feature in Western Australia is the occurrence of *Monilopora nicholsoni* at apparently an indefinite horizon in the Upper Series (which seems

clearly transitional), Mount Marmion. It is claimed in this paper that this is one of the characteristic fossils of the transition series in Queensland (with a range to the Lower Bowen at Springsure), and its occurrence therein with several Lower Carboniferous and many Permo-Carboniferous forms at different Queensland localities would be rather in keeping with Blatchford's report for the Kimberley district. There, its associated fauna, as described by Etheridge, appears to be of an older facies than occurs in either the Lower Marine or Lower Bowen of the type areas in the two States.

Another question that cannot be altogether severed from consideration of a Carboniferous transition in Queensland is the suggested correlation by Whitehouse[67] of Lake's Creek beds, Yatton limestone, and Collinsville Coal Measures. The first is considered by Morton and Reid, on grounds already stated, to be in the Carboniferous transition sequence and *below* the Lower Bowen Volcanic-*Glossopteris* series. As to the two latter the writer cannot accept as even probable their correlation (particularly on the evidence now available as to the position of the Monilopora horizon in the Springsure district) the grounds for which Whitehouse has stated as follows:—

> "The fauna of the Yatton limestone and the base of the Middle Bowen indicates that these beds are a marine equivalent of the Greta Coal Measures. The evidence of this is—
>
> (1) The occurrence in these beds of numerous species (e.g. *Productus farleyensis*, *Martiniopsis branxtonensis*, and *Mœonia minor*) which in N.S.W. belong to the Farley stage—i.e., the top of the Lower Marine.
>
> (2) The occurrence together in these beds of forms which in N.S.W. are restricted some to the Lower and some to the Upper Marine.
>
> (3) The prolific occurrence at this limited horizon throughout Queensland of forms which are not known from the beds in the Hunter River section (e.g. *Productus subquadratus*, *Monilopora nicholsoni*, and a small, new, characteristic productid)."

Before criticising this correlation, it is perhaps only fair to state here that the writer first placed the Mount Britton basal bed at the base of the Middle Bowen, and the Yatton limestone at the top of the Lower Bowen in his reconnaissance survey of the Nebo district. The reasons for since considering necessary their removal to lower horizons are given fully in the portion of this work dealing with the Lower Bowen.

As to (1), it is difficult to see what strength there is in this if the species in question are not considered as of diagnostic value. If by the use of the words "*which in N.S.W. belong to the Farley Stage*" it is meant that their ranges are restricted to that stage, then their present records are completely opposed thereby. All appear to have considerable ranges. In Queensland, *P. farleyensis* ascends to what is considered to be probably the very top of the thick Mid-Bowen marine series at Black Gate, Blenheim (specimen figd., G.S.Q. Pub. No. 276, p. 83). In New South Wales it also occurs in rather high beds of the Upper Marine (Nowra beds). As it has also been recorded at Lake's Creek, it possibly has a very extended range. *Martiniopsis branxtonensis*, a small varietal form of the long-ranging *M. subradiata*, if it should have definite specific value is, of course, a Farley to Branxton species, and has been identified

from my described section low down in the Lower Bowen volcanic series of Tooloombah, Styx district.[68] *Mæonia minor* is, according to Etheridge,[69] practically restricted to the Upper Marine, but also occurs in the Farley beds. One specimen was found in the Mount Britton basal beds, but it cannot be considered a characteristic form from this well-known and frequently examined horizon. Its other Queensland record is from Coral Creek, in the highest section of the Middle Bowen at Collinsville. Further, it should be made clear that not any of the three forms are recorded from the Yatton limestone, so that portion of this statement seems not in accordance with fact.

As to (3), this statement would appear to have value only if the correlations of this limited horizon are securely based on field surveys. The fieldwork alone does not suggest that this is so. It has been stated to be only a reconnaissance survey, and the sections were qualified by the statement that they were only intended to show structure as far as the limited data available served to show. Further, the two beds evidently referred to (Yatton and Mount Britton basal) have some noticeable faunal differences. *Eurydesma cordatum* and *Monilopora*, recorded from Yatton, do not apparently range up to the Mount Britton bed, and it appears a safe inference, both on stratigraphy and fauna, that it is considerably younger than the Yatton limestone. Also, it is not absolutely certain that *Eurydesma* occurs with *Monilopora* in the limestone. It may have come from the higher beds of Bowen marine facies in the same locality, and on the recent evidence of the Springsure section this now seems most probable. Then two forms recorded in the Mount Britton bed, *Aviculopecten mitchelli* and "*Anidanthus*," are in turn not known to range up to the basal marine beds above the Collinsville Coal Measures. As to the three forms mentioned by Whitehouse, *P. subquadratus* (i.e., Morris' species) is indicated herein as having possibly a considerable range in the Lower Bowen, and in New South Wales is recorded from the Upper Marine at Cambewarra (though whether it is there identical with the Lower Bowen species seems at least doubtful) and from Cessnock in the Lower Marine, also in some Drake beds assigned to the northern Lower Marine phase. *Monilopora* is unrecorded from all definite Middle Bowen horizons in the Great Syncline, but has recently been found to occur in a definitely determined horizon in the Lower Bowen, near Springsure, and is also recorded from Yatton and Banana. It is held herein to be probably characteristic of the upper portion of the Carboniferous sequence. The small new productid (elsewhere it is referred to as "*Anidanthus*") may be held to range from the higher Carboniferous to the Mount Britton basal horizon on the determinations of Whitehouse. His correlations and supporting remarks suggest the existence of a very distinct faunal break within the "Middle Bowen," between the base of the series and the higher members. This would seem to be emphasised by a comparison of the faunal lists given herein for the Gympie Goldfield, which he holds for basal Mid-Bowen, with the Bowen Coalfield and its undoubted Middle Bowen equivalents of Logan Downs, &c., and Mount Britton (upper beds).

Summarised, on the lists accompanying this paper, there are at least twelve species and eight other genera shared by both. The "Middle

Gympie'' at Gympie has at least fourteen species and two other genera not present in the Mid-Bowen, while the latter has twenty-eight species and eight genera not present in the former. Little, if any, stress is laid on this numerical method for indicating a break, as it seems both unfair and unsatisfactory for several reasons, and the fossil lists herein would undoubtedly be susceptible to revision if all collections now available were systematically examined and described. What does, in a valid way, appear to indicate an abnormal break, still comparing ''Middle Gympie'' to Middle Bowen of the type field and its named equivalents, is—

(1) The decline of the corals in the Mid-Bowen, the affluence of varied large and small *Stenopora* of five species, including forms in massive colonies, which first appear abundantly in the upper half of the Lower Bowen and are unknown in Gympie and Lake's Creek (compared to one, *S. gimpiensis*), the enormous abundance of *Strophalosia clarkei* and *Productus brachythœrus* attaining large dimensions, the development of giant forms such as *Cleobis* and the larger species of *Mœonia*, &c.

(2) In "Middle Gympie" alone of the two are the Carboniferous types *Monilopora*, *Polypora* (*?*) *smithii* (also at Stanwell), *Rhombopora laxa* (which ranges on the records from Neerkol to the Lower Bowen) while *P. brachythœrus* and *S. clarkei* are unrecorded there.

The above considerations, it is held, indicate a remarkable faunal break within the ''Middle Bowen'' of Whitehouse. It is suggested that no comparable break can be sustained between the wider limits of the Lower and Upper Marine in New South Wales, or between Lower and Middle Bowen in the Great Syncline. The faunal lists admittedly are not entirely satisfactory, but that is owing to the backward condition of descriptive palæontology in Queensland, and doubtless, if all new available material from both localities were described, considerable revision would be necessary.

The writer is of the impression that sufficient detailed fieldwork has not yet been done in Queensland to warrant the detailed correlation of many stratigraphical horizons in the Upper Palæozoic rocks. Until such a firm basis is established, the ranges of numerous fossils ought to be regarded as strictly provisional. His extensive fieldwork on these rocks has, however, produced the opinion that long ranges are common in the Permo-Carboniferous* in conformity with Haig's dictum on the Anthracolithic fauna[70] as to the lack of distinctive faunal records in neighbouring stages and Schuchert's recent statement[71] to the effect that the Upper Carboniferous faunas ascend abundantly into the Permian without much change. It is held that the evidence in Queensland indicates that on the present palæontological records the following common Permo-Carboniferous species, at least, made their first appear-

* This does not invalidate the view held that certain faunal changes are observable in adjacent stages in the Permo-Carboniferous.

ance in the Upper Carboniferous transition series, and therefore below the horizons of the Lower Marine in the Hunter River (N.S.W.) :—

Trachypora wilkinsoni (possible occurrence according to Etheridge[72] in the Carboniferous at Glen William, N.S.W.), *Monilopora nicholsoni*, *Pleurophyllum cainodon*, *Protoretepora ampla*, *Productus farleyensis*, *Dielasma cymbæformis*, *Spirifer vespertilio*, *S. stokesi*, *S. strzelecki*, *S. tasmaniensis*, *S. duodecimcostatus*, *Martiniopsis subradiata*, *Aviculopecten sprenti*, *A. squamuliferus*, *Deltopecten subquinquelineatus*, *D. limæformis*, *Mourlonia strzeleckiana* (also recorded in Rockhampton Series), *Conularia tenuistriata*, *C. inornata*.

The Carboniferous to Permo-Carboniferous marine succession appears to have been deposited in a geo-syncline extending approximately from Bowen southwards into North-eastern New South Wales, and possibly approaching, at points inland, to longitude 148° E. in Queensland. Towards the end of the Carboniferous period paralic deposits appear to have been the rule following oscillation, but marine egression occurred, and during either the Lower or Middle Bowen period the sea extended at least well towards the 147° E. longitude in the Springsure region. The geo-synclinal evidently extended into approximately Middle Permian time under partial marine conditions, and it is now suggested that it might be called the **Capricornian Geo-syncline,** after the well-known Central Queensland district.

VII.—THE SILVERWOOD BLOCK FAULTS.

The Permo-Carboniferous rocks in the Warwick-Stanthorpe districts have been described by Richards and Bryan,[73] who have devoted considerable research to the elucidation of a complex area. Their interpretations in several respects are considered to be so much at variance with what has since been discovered as to the succession, orogeny, and relationships of Permo-Carboniferous rocks in many other portions of Queensland, that it is suggested the authors might consider a review of the interpretation of their data in the light of the results obtained elsewhere in the State since their work was done. It is only the great divergence mentioned above, as well as the considerable amount of work done on the Queensland Permo-Carboniferous, that induces the writer to take up this criticism in view of his limited acquaintance with the area—confined to a cursory examination of the Eurydesma and Wallaby beds. A critical examination of all the literature pertaining to the later Palæozoic rocks in Queensland, as well as a study of evidence relating to the earth movements of the period involved, has been responsible for a disagreement with the interpretation of the geology of the Fault Block Series on two points, viz., the correlations adopted and the interpretation of earth movements in that area, in so far as they relate to the subsidiary *rôle* of the late Permo-Carboniferous folding compared to a stated late-Devonian mountain-making movement.

(1) Correlation of Fault Blocks.—The Eurydesma beds are alone correlated with the Lower Marine (i.e., approximately Lower Bowen) ; all the other beds are grouped in horizons ranging from the Greta coal measures through the Upper Marine to the Middle coal measures, or in

terms of Queensland equivalents, from about the base of the Middle Bowen to the lower beds of the Upper Bowen. These placements

"are based primarily on the assumption that *Eurydesma cordatum* and *Trachypora wilkinsoni* occupy the same respective horizons in both areas (i.e. Hunter River and Silverwood) and that the predominance of *Gangomopteris* over *Glossopteris* in the lower portion of the Wallaby beds warrants a close comparison with the Greta coal measures."

Whatever force these three assumptions had in 1924, it is not too much to say that the last has been invalidated, if not disproved, by recent work in Queensland and that the second was open to the objection that *Trachypora wilkinsoni*, while forming a typical Upper Marine horizon in the Hunter River, had been recorded from areas at Kempsey and Boorook, whose stratigraphical horizons had not been fixed. This has resulted, from its association with *Monilopora nicholsoni* and *Cladochonus* sp. in the Condamine Block fault, in the two latter forms, which are not recorded from either the Upper Marine or Middle Bowen in the type areas, being elevated to the unexpectedly high horizon of the Upper Marine.

[R. and B. " the presence of such typically Carboniferous genera as *Cladochonus* and *Monilopora* in beds which are attributed to the Upper Marine phase of the Permo-Carboniferous period is somewhat surprising . . ."]

Cladochonus appears a characteristic Lower Carboniferous genus in New South Wales. *Monilopora nicholsoni* has, outside of Queensland, been recorded from the Upper Carboniferous beds of Kimberley,[74] but with a very different association from that which obtains in the Upper Marine of New South Wales. Amongst presumably older forms with which it is associated there are *Favosites marmionensis, Evactinopora (Hexagonella) crucialis, Rhombopora tenuis, Reticularia* sp., &c. The New South Wales and West Australian evidence, in the opinion of the writer, should have weighed against using *T. wilkinsoni* as a diagnostic form for the Upper Marine, and the interpretation of Upper Palæozoic stratigraphy advanced herein considers it, in Queensland, a Monkland to Lower Bowen form without a record in the type area of the Middle Bowen.

The Block Fault correlations seem to the writer to now have two very great improbabilities, viz., (*a*) the presence of a thick series of volcanic flows on such a high Bowen horizon in Queensland, and (*b*) a very real difference of sedimentation from the beds with which they are correlated in the type areas, both to the north and south of the Silverwood region. Neither improbability renders the correlations invalid, of course, if the other evidence is convincing. Both are considered below.

(*a*) The volcanic flows, 2,500 ft. and 1,000 ft., at the top of the sections in the Eight-mile Creek and Tunnel blocks, respectively, have been placed in the Upper Marine and correlated with the volcanics of the Southern Coalfield of New South Wales (Kiama, &c.). The correlation is exceedingly improbable, firstly because (1) as Richards and Bryan justly point out, they are chemically and petrologically quite distinct; also Kiama is over 400 miles away, and a very unique petrological province, while intermediate regions of the Upper Marine are

apparently devoid of volcanics of this type, and probably of any other except an occurrence of doubtful horizon at Murrurundi. Supporting Richards and Bryan's statement of differences between Kiama and Silverwood volcanics is the recent testimony of Browne,[75] who says of the former group—"Petrologically they are entirely different from anything else in the way of volcanic rocks hitherto discovered in the State or even in the Continent." (2) The Upper Marine period was volcanically the most quiescent of the Bowen formations in Queensland based on other assured areas, and there are up to the present no records of flows in the definite Middle Bowen. This is in harmony, for the same period, with Sussmilch's statement[76]—

"Although the Upper Marine Series have a thickness of about 6,000 ft. in the Hunter River district they contain no volcanic rocks."

(3) The important volcanic series of the Lower Bowen indicates very wide lava spreads throughout coastal and central Queensland south of Bowen, with apparent equivalents reaching as far as the Hunter River. (4) The Stanwell Lower Bowen section is broadly analogous to the 3,700-ft. upper section of the Eight-mile Creek (except for 75 ft. of marine sandstones in the latter), in both of which black *Glossopteris* shales interbedded with conglomerates range up into massive rhyolites, andesites, &c.

(*b*) Geological survey work in Queensland seems to indicate a marked, widespread, and apparently almost constant difference in the marine sediments of the Carboniferous transition ("Carboniferous type") as opposed to those of the Bowen Series ("Permian type"). The former are prevailingly fine-grained, usually dark to black densely consolidated muds; the latter normally are lighter coloured, coarser grained sandstones, &c., weathering with exceeding rapidity. These types are constant for both the Lower and Middle Bowen Marine sediments in the Great Syncline over a distance of about 400 miles from Collinsville to Springsure (and also on the coastal area in the Styx district) with the one known exception of the Yatton limestone zone, in which individual beds approximate to the "Carboniferous" type. In the main the Bowen types are susceptible to extremely rapid erosion, and form a marked contrast to the hard, resistant, and often indurated shales, slates, or mudstones of the following areas:—Neerkol, Gympie, Silverwood, Silverspur, and Drake. Freshwater *Glossopteris* beds in the Lower Bowen, however, are frequently of the dark "Carboniferous" type. The Bowen sedimentary types are predominating in the Hunter River, thus indicating wide uniformity of "Permian" sedimentary conditions. The two types are exceedingly distinct as between the lowest and highest formations, with some alternations in the lower beds of the Lower Bowen, that is to say, in the "changing-over" period induced by elevation of the sea bottom with resulting boulder beds and paralic sedimentation.

Leaving discussion of improbabilities, the Stanwell-Neerkol section has shown that beneath the main mass of Lower Bowen volcanics *Glossopteris* ranges to at least about 1,500 ft. lower; some 5,000-6,000 ft.

lower still than our first record of that flora, it is possible to get in Neerkol beds a Carboniferous fauna with the first representative of the Permo-Carboniferous (*Protoretepora*), in association with a transition-period form (*Pustula*) which appears so far in neither the Burindi-Rockhampton nor the Lower Bowen. This looks to be the form doubtfully ascribed by Etheridge from this locality to Sowerby's species *P. brachytherus*. At higher horizons are species of *Polypora* (*?*) and *Rhombopora* which elsewhere (Gympie, &c.) are found mixed with numerous elements of the Permo-Carboniferous fauna. There are the old and doubtful records of *Spirifer vespertilio* and *Martiniopsis subradiata* from indefinite horizons. That such a characteristic Permo-Carboniferous assemblage as comes from beneath the Rhyolite Range rhyolites is not obtained at Stanwell can be considered as evidently due to the fact that marine beds do not exist there immediately below the main volcanic horizon. But at Lake's Creek rather a striking Permo-Carboniferous assemblage with several lower species occurs in beds apparently ranging conformably upwards from the Rockhampton Series and, on grounds already defined, the former series is correlated, in part, by Morton and the writer with the upper portion of the Neerkol Series and placed *below* the Lower Bowen.

The Condamine beds of the Silverwood block faults, placed in the Branxton stage of the Upper Marine, have two or possibly three characteristic Queensland species in *Cladochonus* sp., *Monilopora nicholsoni*, and *Productus* (*"Anidanthus"*) sp., which do not occur in the Upper Marine or Middle Bowen. Of these the first is a common Burindi genus, and the second seems particularly characteristic of the Gympie horizon. The Branxton (N.S.W.) glacials are well represented in Queensland with their enormous development of *Strophalosia*, *Chœnomya*, and *Productus brachytherus*, so that (in addition to the Lower Permo-Carboniferous species present) the absence of these three forms is particularly striking at the Condamine block. It is very difficult to conceive of beds about this horizon in Queensland without abundant *Strophalosia* zones. On the above palæontological and lithological evidence, it is considered that this block is certainly on the lowest stratigraphical horizon of those described from Silverwood, and is of the transition series which it is proposed should be covered by the revised Gympie Formation. The other blocks described are considered to be partly, at least, on low horizons in the Lower Bowen of Queensland, and lithological comparisons might be made in respect to the presence of marine and volcanic beds of approximately this age with the Tooloombah (Styx) section and, as to freshwater beds, with the Stanwell (Dinner Creek) section.

(2) Evidence re Folding of Fault Block Areas.—The data used to support a late Devonian mountain-making movement in this area, in so far as it relates to folding subsequent to the age of the Middle Devonian Burdekin beds in Queensland, are, it is held, unsupported by the evidence in this paper as to the apparently confermable passage upwards from the Burdekin and Lower Star to Upper Star, with a

localised area of folding about the Middle period of the Carboniferous, or by the evidence of Benson in Western New England as to the perfectly conformable relationship there between Devonian and Carboniferous. Andrews,[77] for the Permo-Carboniferous of Silverwood and Drake districts, previously considered them intensely folded, faulted, and intruded, and Ball[78] regarded the Carboniferous to the west of Silverwood as excessively folded, and also the Permo-Carboniferous of Silverspur as evidencing folding[79] on account of tilting, crushing, and rock plication. Carne also obtained marine fossils of apparently this period in the folded beds of the Vegetable Creek district.[80]

Reference to the sections A and B of Richards and Bryan[81] shows three infaulted Permo-Carboniferous blocks in the enclosing Devonian strata, and in each instance they are together dipping towards the same general direction. As to dip angles:

Silverwood (Devonian) Series (p. 55)—

"The dips are always steep so that 60 degrees may be regarded as quite a conservative estimate of the average."

Permo-Carboniferous Series, *Eurydesma* Block (p. 61)—

"For the most part dip steeply to the west although in the immediate neighbourhood of the boundary faults the dip is often erratic."

Eight-mile Creek beds (p. 61)—

"The dip . . . ranging from 60 degrees in the lower beds to 40 degrees in the upper. Assuming 50 degrees as the average dip . . ."

The view is advocated that these frequent steep dips are only consistent with the late-Permian folding of Eastern Queensland.

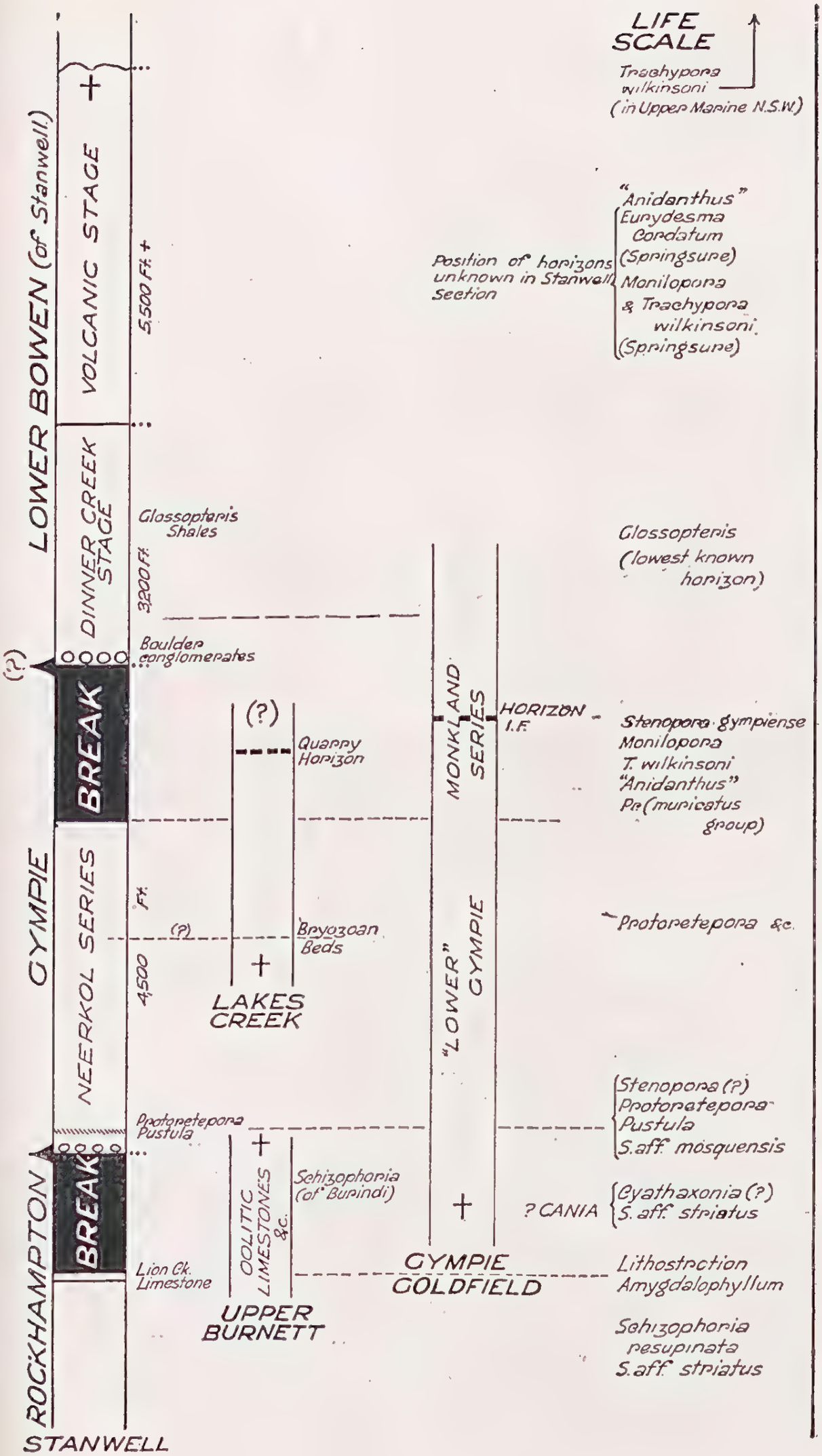
The Silverwood area adjoins that region in New South Wales in which Browne[82] has shown that the Upper Palæozoic strata are appreciably folded and intruded.

In considering the limited knowledge of the Queensland Permo-Carboniferous, at the period when the Silverwood investigations were carried out, no one appreciates more than the writer the difficulties that must have then confronted the problem of the correlation of those separated areas.

VIII.—THE GYMPIE FORMATION.

No formation in Queensland has given rise to so much confusion or vexatious uncertainty. It has been placed as between "probably Upper Silurian" and Middle Bowen (in part) by various geological writers between the year 1868 and the present day. For a concise statement as to the vicissitudes of its classification reference should be made to Bryan's "A Glossary of Queensland Stratigraphy," p. 33.

As explained in the Introduction to this paper the Gympie Formation was never defined—the term was ambiguous and evidently represented, in Jack's opinion, a folded and indurated black slate, &c., series which he distinguished from the Bowen formations, and apparently regarded as homotaxial with the European Carboniferous. Jack's opinion that the Gympie of the type area was stratigraphically lower than



ATTEMPTED CORRELATION OF SEVERAL CARBONIFEROUS, &c., SECTIONS
(*Stenopora gympiense* should read *Stenopora gimpiensis*.)

the Lower Bowen is entirely supported in this paper, and it is now proposed to define a Gympie Formation for discussion, mainly on the basis of the Gympie and the Neerkol sections, the latter of which, on combined stratigraphical and palæontological evidence, must evidently belong to the older division of the Upper Carboniferous, and eventually, after at least one marked break in sedimentation, reaches the Lower Bowen containing the *Glossopteris* flora. The flora equivalent to the marine horizon of the Gympie Goldfield is not known, but on the basis of two sketch sections at St. Helens and Oakey Creek, as well as an observation by Tenison Woods on a Gympie fossil plant, it is thought to be rather probable that it may prove to be antecedent to *Glossopteris*. Apparently the only plant remains that have been found in the type area came from the Lady Mary shaft, in the Middle Gympie, and Tenison Woods compared them to *Cordaites australis* of the Upper Star (Lower Carboniferous ?) Series. (See "Geol. and Pal. of Q'ld.," p. 198.)

The appearances at present are that the Permo-Carboniferous fauna, as rather typically developed, made its first appearance towards the latter part of the Upper Carboniferous sequence and, if anything, slightly preceded the *Glossopteris* flora. It is suggested that the Gympie Formation might be considered as extending down to the base of the Neerkol Series and upwards to take in such marine horizons as the Lower (in part), Middle, and Upper (in part) Gympie (of Gympie Goldfield), Lake's Creek, &c. The association of volcanics with *Glossopteris* might, as at Dinner Creek, Stanwell, be provisionally considered as indicating the Lower Bowen Series upwards. It seems impossible at present, without the definition of faunal zones, to draw a dividing line between a marine sequence from the Gympie to the Lower Bowen, if such should exist in any specific locality.

Etheridge Senr.,[83] in examining Daintree's collection from the Gympie Goldfield, placed their age as Devonian, but yet observed at least one form (*Productus cora*) that was common in the Carboniferous rocks of Europe and unknown in the Devonian, as well as others with Carboniferous affinities. It is not, therefore, surprising that Jack,[84] commenting on his determinations, stated—

> "The balance of evidence, therefore, . . . appears to have been in reality much in favour of a homotaxial relation with the European Carboniferous."

In 1892 Jack placed the Gympie Formation at the base of the Permo-Carboniferous system as following, in stratigraphical sequence, the Middle Devonian Formation of the Burdekin River in the Queensland Geological Record. In the meantime, however, Etheridge Junr. in 1889 had examined the collection of Rands, and was cited by him[85] as regarding them as showing close relation to the Carboniferous and Permian Formations, and as identical with those of the Bowen River Coalfield. If cited correctly, exception may be taken to-day to the latter portion of the reference, for at least six species in his list in Rands's report[86] have never been recorded from the Bowen field (i.e., Middle Bowen), and do not appear in his lists of the life of either the Middle or Lower Bowen Formation. Nor can the statements of that

period be accepted to-day, apparently because of the imperfect stratigraphical records, for Etheridge[87] showed in 1892 that the Middle Bowen Series had twelve species in common with the Star, and seventeen in common with the Gympie. The faunal lists given in this paper do not allow positively one common species in the Middle Bowen and Star. It is difficult now to understand why importance was not attached to Etheridge's determination of Carboniferous types such as *Rhombopora laxa, Polypora* (?) *smithii, Leptæna analoga,** and others in association with a fauna of Permo-Carboniferous facies, and their absence from the Bowen (Q.) and Hunter (N.S.W.) districts.

This position in the Permo-Carboniferous was retained until 1916, when Dunstan[88] placed the "Lower Gympie" Series tentatively on the horizon of the Rockhampton Series, the "Middle Gympie" as the Lower Marine Series, with other parts of the series in higher divisions of the Permo-Carboniferous. Dun appears to have concurred with Etheridge Junr. as to the Permo-Carboniferous facies after an examination in 1923 of the Geological Survey collection of fossils from the Gympie field, in considering them as of Lower Marine (N.S.W.) age, and probably this verbal opinion finally decided the official acceptance by the Queensland Geological Survey of their equivalency with the Lower Bowen and the deletion of Gympie as a separate series from the State Geological Record on the proposed new Queensland Map (1928). Whitehouse[89] in 1928 correlated them with the base of the Middle Bowen.

In Queensland, according to the definition in this paper, the Gympie Formation seems to be the only one that can legitimately aspire to the position of chief time equivalency with the Kuttung in New South Wales, and its claims in that connection have been mentioned elsewhere with regard to stratigraphical succession and glaciation.

It is necessary to make clear that the revised Gympie Formation is not considered tied to any fixed part of the Carboniferous (that should depend on a critical examination of the fauna from a number of separate areas, though it obviously seems entirely within the Upper Carboniferous), but that it is considered definitely intermediate in age between the Lower Carboniferous (of the Rockhampton-Burindi) and the Lower Bowen. It holds this position by virtue of the intermingling of older and newer forms, and its apparent relationship with rocks of the Rockhampton Series. The evidence as to some occurrence of glacials in the Gympie, the absence of typical freshwater Kuttung deposits within the area of the Carboniferous marine geosyncline, and the mingling of the faunas alluded to make it seem certain that the formation, as defined in this paper, must be contemporaneous to a marked degree with the Kuttung.

Stanwell Area.—The determination by Morton and the writer of the angularly conformable relationship of the Stanwell Marine (now Neerkol) Series (containing several Permo-Carboniferous faunal forms) to other definite geological formations dates from the work carried out in Central Queensland in 1928.[90]

* See footnote (*a*), fossil table IV., as to probable mistaken identity.

REID AND MORTON'S STANWELL DISTRICT SECTION
(Emended).

Mesozoic	Stanwell Coal Measures.
	UNCONFORMITY.
Permo-Carboniferous	{ Lower Bowen Volcanics (est.) 5,500 ft. { Dinner Creek Series (with *Glossopteris*), (est.) 3,200 ft.
	STRATIGRAPHICAL BREAK.
Upper Carboniferous	Neerkol Series (est.) 4,500 ft.
	DISCONFORMITY.
Lower Carboniferous ..	{ Lion Creek Limestone { Rockhampton Series }

The Stanwell area had been previously examined by Dunstan,[91] and his last map and section on the area shows the Neerkol Series as of Gympie age, together with the Lion Creek Limestone and some of the Rockhampton Series, which was in accord with the official view of the Gympie Series at that period. He showed the Dinner Creek Series as of Upper Bowen age, lying conformably on the Gympie beds, and what are now known as the Lower Bowen volcanics as doubtfully of Gympie age and probably faulted against the Dinner Creek Series. There is, however, a gradual transition of *Glossopteris* shales and volcanics from the latter series upwards till the former entirely give place to massive andesites, &c., which, steeply dipping, lie conformably on the Dinner Creek Series, which is regarded as the lowest horizon of *Glossopteris* yet placed in Queensland. This transition has been definitely established by detailed examination, and obviates the necessity for apposing the probable unconformity mentioned, and places the Gympie (?) as the Lower Bowen volcanics of younger age than the Dinner Creek Series.

Gympie Goldfield.—Descriptions of the Gympie Goldfield section are given in Rands's[92] reports, and also in Jack and Etheridge,[93] which are largely transcriptions from the former. The section is made up mainly of fossiliferous shales (the auriferous "black slates"), impure limestones, greywackes, sandstones, conglomerates, and interbedded volcanic rocks. These rock types as a group are foreign to the Lower and Middle Bowen Series of the Great Syncline, except to some extent in the Yatton limestone belt. The section shows considerable rock alteration and induration as well as intrusion by later igneous rocks. Its relations to neighbouring geological formations appear to have not then been satisfactorily defined. Dunstan[94] later divided the auriferous and associated rocks into "Upper, Middle, and Lower Gympie," all of stated Permo-Carboniferous age. Both Rands and Dunstan have shown a large series of faults, of which several are of considerable magnitude, but neither shows by this faulting the introduction of possibly older or younger rocks than the "Middle Gympie" Series within the auriferous belt from which Rands obtained his collection of fossils, described by Etheridge. Dunstan shows three volcanic

groups within his "Middle Gympie," and in 1916, as mentioned previously, doubtfully placed his "Lower Gympie" Series in the Rockhampton Series, and this would not be in disaccord with the succession advanced in this paper as would the *probable* unconformable relationship of the "Lower and Middle Gympie" which he mentions, and which is discussed elsewhere.

The first collection of marine fossils, with the exception of a few by Clarke, was made by Daintree and described by R. Etheridge, F.R.S.[95] Exact localities are not given for all the specimens, and to obviate any possibility of a mistake such as arose at Rockhampton, in that forms from at least two different and apparently conformable formations were intermixed under the "Gympie" Formation of "Permo-Carboniferous" age, we may note that in Daintree's collection the following forms were described from localities which are within the "Middle Gympie" of Dunstan:—

Leptæna analoga	Lady Mary Reef
Spirifer undifera var. *undulata*	Lady Mary Reef
Fenestella fossula	Smithfield Reef.

The collection of Rands and Jack, described by Etheridge Junr.,[96] need not be repeated in detail here, but such Carboniferous types as *Rhombopora laxa, Productus semireticulatus, P. cora, Leptæna analoga* were listed in association with a dominant Permo-Carboniferous fauna containing *Protoretepora ampla, Spirifer strzeleckí, S. vespertilio,* &c. Of these, *P. semireticulatus* was not listed from Gympie in his revised list of fossils of the Permo-Carboniferous system.

From this list of fossils may be extracted the following which have precise localities or horizons that are definitely in the "Middle Gympie" of Dunstan:—*Stenopora gimpiensis, Fenestella fossula, Polypora (?) smithii, Spirifer strzeleckí, Leptæna analoga, Productus cora.* In this horizon *Monilopora* and "*Anidanthus*" have since been collected.

The above lists show some commingling of Carboniferous and Permo-Carboniferous types which is common to many localities in Queensland, e.g., Yarrol, Cania district, &c.,and in New South Wales, as in the Drake-Kempsey districts, &c.

It need not be admitted that the other forms mentioned in these collections did not come from the same horizon, for a number of them are present in Permo-Carboniferous beds of undoubted position either in the Bowen Series of Queensland or in the Lower and Upper Marine of New South Wales. It is indeed the auriferous belt of the Gympie Goldfield that has been the chief, if not the entire, collecting ground of the Gympie fossils. Rands[97] confirmed this in stating that although he has searched over most of the country around Gympie he had never come across fossils in any quantity outside of the auriferous belt.

Other Probable Gympie Areas.—Jack placed very large areas of Gympie on the State Geological Map in the Central and Southern coastal areas. While it is true, as Jensen and others have suggested, that

too much has been put into the Gympie, the writer believes that Gympie must be largely present in that area, based on tectonic and palæontological evidence. Localities such as Yarrol, parts of Cania district, Lake's Creek, and Collaroy are localities where Permo-Carboniferous and Lower Carboniferous types appear, on the existing records, to be mixed together, suggesting correlation with the series. Many "Permo-Carboniferous" areas are indicated on Ball's geological sketch map of the Gladstone-Upper Burnett district,[98] some of which are probably of Gympie age. Further, most areas of what are herein considered Gympie strata appear generally impoverished as to organic remains, and many apparently unfossiliferous areas of essentially dark-coloured, indurated rocks which may at present be thought to be older will, it is considered possible, prove to be of Gympie age as detailed survey progresses. In this connection, although abundant fossils have been collected, experience seems to indicate that one bed may have an overwhelming abundance, but the great bulk of the beds are barren of visible remains.

In the Texas-Warwick district, on the New South Wales border, Skertchly[99] mapped all the sedimentary rocks as Gympie on lithological evidence allied to the presence of fossils about Silverspur, and the presence of *bryozoa, Productus*, and *Spirifer* in similar beds in the district near Glenlyon.[100] Later, Ball[101] confirmed the "Permo-Carboniferous" age of beds near Silverspur with evidence of *Polypora (?), Productus brachytharus, P. undatus*, &c., and *Aviculopecten*, &c. Another area of "Permo-Carboniferous" has been mapped by him some miles further south-east, and with the Glenlyon area of Skertchly we may conclude there is evidence of a scattered and rather numerous distribution of "Permo-Carboniferous" rocks throughout the district similar to that shown by Richards and Bryan in the Silverwood district in an area which also contains Devonian limestones, and in the Drake (N.S.W.) district, which Andrews[102] considers identical with the Warwick-Silverwood region. Ball,[103] however, sees no justification for removing the main mass of rocks, enclosing those of the "Permo-Carboniferous" in the Texas district, from the Carboniferous system on account of their resemblance to those in association with the fossiliferous limestone of Texas. It is suggested that the "Permo-Carboniferous" beds of Silverspur are of Gympie age on account of the general and often specific lithological resemblance to rocks of the Gympie Goldfield and Neerkol Series, and their utter dissimilarity to the marine formations known in the Middle and Lower Bowen Series of the Great Syncline of Queensland; also the possibility of the two productids being the species listed and described by Etheridge[104] as *P. undatus* and *P. brachytharus* from Stanwell, and, lastly, Whitehouse's determinations of a small collection by Denmead from the area. Ball[105] describes the "Permo-Carboniferous" strata in the following terms:—

> ". . . variably metamorphosed . . . crushed pebbly grits . . . fossil remains crushed out of all recognition . . ."

REFERENCE

AREAS CORRELATED WITH THE –

1. STAR FORMATION
2. ROCKHAMPTON SERIES (LOWER CARB.)
3. GYMPIE MARINE SERIES (UPPER? CARB.)
4. BOWEN " " (PERMO CARB.)

APPROX. LINES LIMITING OUTCROPPING AREAS OF :–

ROCKHAMPTON SERIES
GYMPIE MARINE SERIES
BOWEN " "

DOUBTFUL AREAS OF FRESHWATER BEDS OF GYMPIE AGE

BY

J. H. REID

QUEENSLAND GEOLOGICAL SURVEY

100 75 50 25 0 100 200 MILES
APPROXIMATE SCALE

PASCOE R.
HODGKINSON FIELD
SILVER VALLEY
CLARKE R.
STAR R.
UKALUNDA
MT WYATT
COLLINSVILLE
ST HELENS
LOGAN DOWNS
YATTON
CLERMONT
OAKEY CK
STYX
TOOLOOMBAH
DRUMMOND RANGE AREA
SPRINGSURE
STANWELL
ROCKHAMPTON
BARMUNDOO
CANIA
MONTO
CANNINDAH
CRACOW
(?) GYMPIE
CRESSBROOK CK
BRISBANE
SILVERWOOD
SILVERSPUR
TEXAS

NATIONAL ... VICTORIA

N. S. WALES

At a later date than the Silverspur report, the same authority wrote of the surrounding Lower Carboniferous rocks—

"Between Gore and Cobba-da-mana these schistose shales everywhere are steeply tilted and multiple folding is suspected but compression has been so intense that more than cursory inspection is requisite for its unravelling."

There appears to be no evidence of the existence of marine formations of Gympie age in North Queensland. Palæogeographical conceptions of the writer do not favour the existence of marine sedimentation there during that period.

Relation of Gympie and Lower Bowen.

The evidence presented seems conclusive that the Gympie Formation cannot be contemporaneous with any portion of the Middle Bowen. The question then naturally arises as to its relationship with the Lower Bowen. To that the answer appears to be that there are many faunal relationships, but also a number of important faunal differences, that the marine lithology as a series is distinct, and that the stratigraphical investigations of Morton and Reid into the position of the higher beds of the Gympie Formation (as revised herein) indicate most strongly that they are on lower horizons than the thick series of Lower Bowen volcanic rocks in the coastal region with which are intercalated beds with the *Glossopteris* flora and certain characteristic marine forms of the Bowen formations as *Eurydesma cordatum*.

In comparing the Gympie (Monkland) type area with the Lower Bowen of the Great Syncline, it is found that the corals *Trachypora wilkinsoni* and *Monilopora nicholsoni* are common to both, but the former must be disregarded as of value for correlation on account of its apparent long range. The range of *M. nicholsoni* cannot be regarded as known, but at least it ascends towards a mid-position in the Lower Bowen. Not any of the following diagnostic forms of the latter series occur at Gympie, viz., *Productus* (*?*) *subquadratus*, *Eurydesma cordatum* (or other species), or *Aviculopecten mitchelli*. The very typical Bowen *Productus* (*P. brachytherus*) is likewise absent at Gympie, although it is relatively common in the Lower Bowen and ranges down almost to its base at Springsure. It is, however, in the bryozoans that probably the greatest time difference, based on life evolution, is apparent, and more so in that peculiarly characteristic Permo-Carboniferous group *Stenopora*.

The small ramose form *S. gympiensis* is the only one occurring at Gympie, whereas on the Dilly horizon (probably = to Allendale, N.S.W.) the larger dendroid forms (such as the *ovata* type) are abundantly developed, and there also occurs the lowest known examples in Queensland of massive zoaria (*S. crinita*). In addition, the Bowen species *Polypora pertinax* and *Fenestella internata* are not recorded at Gympie, but *F. fossula* is present in both. *Polypora smithii* of Gympie does not ascend higher. *Rhombopora laxa* ascends from the Neerkol beds through Gympie to the Dilly *Eurydesma* horizon.

What slight palæobotanical evidence is available (*? Cordaites australis*) suggests a pre-*Glossopteris* flora for Gympie.

The present conclusion of the writer based on all grounds is that the Middle Gympie beds of the Gympie field are *entirely* older than the recognised Lower Bowen of the Great Syncline, the Dinner Creek *Glossopteris* beds, and the Lower Marine of the Hunter River (N.S.W.), but that the numerous faunal relationships must indicate some propinquity in time with the lower beds of those formations.

TABLE IV.

FOSSILS RECORDED FROM AREAS CORRELATED WITH THE **GYMPIE** FORMATION.

(It is suggested that notes on Table IV. be first consulted.)

—	Gympie.	Lake's Creek.	Stanwell (Neerkol, &c.)	Spring Creek, Camia.	Yarrol.	Silverspur.	Cressbrook Creek.	Condamine River near Warwick.
Trachypora wilkinsoni Eth. fil.	x	x	..	..	..	..	x	x
Trachypora sp. nov.	..	..	..	..	..	..	..	(?)
Monilopora nicholsoni Eth. fil.	x	x	..	..	..	sp.	x	(?)
Cladochonus sp.	..	..	..	..	..	..	x	x
Pleurophyllum cf. *cainodon* de Kon	sp.	..	..	..	..	x	sp.	
Pleurophyllum gregoriana	..	..	..	..	..	..	..	x
Stenopora gimpiensis Eth. fil.	x (f)	..	sp. ?	..	..	..	sp.	
Poteriocrinus crassus Miller (?)	..	..	x (f)					
Protoretepora ampla Lonsd.	x	x	sp.					
Polypora (?) *smithii* Eth. fil.	x (f)	..	x					
Rhombopora laxa Eth.	x (f)	..	x					
Fenestella fossula Lonsd.	x	x	x (?)	..	..	..	x cf.	
Fenestella internata Lonsd.	..	..	x (f)					
Fenestella sp.	x	..	x	..	x (p)	x	..	x
Lingula mytiloides Sby. (?)	..	..	..	x (f)				
Leptæna analoga Phill.	x*a*	..	..	..	x (p)			
Orthotetes sp. nov.	sp.	..	sp.					
Chonetes sp.	x							
Strophalosia cf. *clarkei* Eth.	x	..	..	..	..	..	sp.	
Productus farleyensis Eth. & Dun	x	x						
Productus cora D'Orb.	x	..	?(f)*b*					
Productus sp.	..	..	..	..	x (f)	..	..	x
"*Productus* (?) *subquadratus*"	..	x*c*	(?)					
Productus (sp. *muricatus* group)	..	x						
Productus ("*Anidanthus*") sp. nov.	x	x	..	..	..	x		
Productus ("*Pustula*") sp. nov.	..	..	x					
Productus semireticulatus Martin sp. (?)	..	..	..	x				
Productus brachythærus Sby.	..	..	? (f)*e*	x	x	x (p)		
Productus undatus	..	..	..	..	..	x (p)		
Dielasma cymbæformis Morr.	x							
Dielasma cf. *amygdala* Dana	..	..	x					
Rhynchonella sp.	..	..	..	..	x (p)			
Spirifer aff. *mosquensis* Fischer	..	..	x					
Spirifer respertilio Sby.	x (f)							
Spirifer trigonalis var. *acuta* Eth.	x (f)							
Spirifer dubia Eth.	x (f)	..	..	..	..	..	x cf.	
Spirifer duodecimcostatus McCoy	x							
Spirifer stokesii Konig	x (f)							
Spirifer Strzelecki de Kon	x (f)							
Spirifer tasmaniensis Morr.	x cf.	x						
Spirifer spp. indet.	..	..	x	..	x (p)			
Martiniopsis subradiata Sby.	x	x cf.	x (f)*g*					
Martiniopsis Morrisii Eth. fil.	x	..	..	x (f)				
Martiniopsis branxtonensis Eth. fil.	x cf.							
Sanguinolites concentricus Eth.	x (f)							
Mæonia (?) *obovata* Eth.	x							
Chænomya (?) *etheridgei* de Kon	(?)							
Cleobis cf. *recta* Eth. fil.	x							
Cleobis sp. cf. *grandis* Dana	x							
Pachydomus spp.	x							
Conocardium (non *australe*) McCoy (*h*)	x (f)							
Aviculopecten (?) *imbricatus* Eth.	x							
Aviculopecten multiradiatus Eth.	x							
Aviculopecten squamuliferus Morr.	..	x (p)	x (p)					
Aviculopecten sprenti Johnston	..	..	..	..	..	..	..	x
Aviculopecten engelhardti Eth. fil. & Dun	..	..	..	..	..	(?)	x	
Deltopecten limæformis Morr.	x							
Deltopecten subquinquelineatus McCoy	x							
Deltopecten sp. nov.	x							
Mytilops (?) sp. ind.	x (f)							
Astartella (?) *rhomboidea* Eth. fil.	x (f)							
Parallelodon aff. *costellata* McCoy	..	..	x					
Nuculana sp.	..	..	x					
Cypricardella jackii Eth. fil.	x (f)							
Pleurophorus randsi Eth. fil.	..	..	..	..	x (f)			

FOSSILS RECORDED FROM AREAS CORRELATED WITH THE **GYMPIE** FORMATION—*continued.*

	Gympie.	Lake's Creek.	Stanwell (Neerkol, &c.)	Spring Creek, Cania.	Yarrol.	Silverspur.	Cressbrook Creek.	Condamine River near Warwick.
Pleurotomaria carinata Sow. (?)	x (f)							
Pleurotomaria	..	..	..	..	x (p)	..	x	x
Ptycomphalina	x	..	..	..	..	..	..	x
Mourlonia strzeleckiana Morris	x	..	sp.	..	x	..	sp.	
Platyschisma oculus Sby.	x cf							
Yrania koninckı Eth. fil.	..	x						
Bellerophon (*Warthia*) *micromphalus* Morr.	x							
Naticopsis	..	..	..	..	..	..	..	x
Murchisonia (?) sp.	x	..	..	..	..	..	..	
(?) *Macrocheilus*	..	..	..	..	..	..	..	x
Goniatites (?) sp. ind.	x (f)							
Conularia tenuistriata McCoy	x							
Conularia inornata Dana	x							
Conularia	x (f)	..	..	..	..	..	..	x
Orthoceras cf. *striatum* Sby.	x	..	..	..	sp. (p)			
Cordaites australis McCoy (?)	x (?)							

Blackfellow's Diggings, Rockhampton, listed by Jack appears, like Lake's Creek, to be of Gympie age on account of the occurrence of *Protoretepora ampla* and *Polypora* (*?*) *smithii*.

x Indicates the particular species listed (with qualifications indicated), but sp. in locality columns indicates the occurrence of the genus only (species not determined), (p) prov. det., (f) specimen figured.

a *Leptæna analoga* always listed by Etheridge Junr. is not recorded in Dr. Whitehouse's list of Gympie fossils. He considers they should be referred to "*Anidanthus*."

b *P. cora* from Stony Creek, Stanwell, appears to be *P. farleyensis* (Eth. pl. 13, fig. 1, Q.G.S. Pub. 92). Evidently from a creek boulder.

c Apparently not the Lower Bowen form (Morris's species) of Mount Britton, Yatton, &c. Etheridge has not described nor figured any specimens from Lake's Creek though he recorded it as the same species (see this paper, p. 64 and p. 72).

d Determination by Mr. W. S. Dun, Palæontologist N.S.W. Geol. Survey.

e *P. brachythærus* from Stanwell is recorded by Eth. from two valid localities but his fig. (pl. 13, f. 5), from an indefinite locality and doubtfully regarded by him as the species, more resembles *Pustula*, so this record for Stanwell and all Gympie localities quoted is not expected to stand.

g The Stanwell specimen of *M* (*?*) *subradiata* is not mentioned by Eth. in text of Geol. and Pal. of Q'ld but is figured in that work, pl. xi., f. 14.

h See Etheridge, Rec. N.S.W. Geol. Sur., vol. 7, pt. 2.

REFERENCES FOR RECORDS IN TABLE IV.

Gympie	R. E. Etheridge, Junr., Geol. and Pal. of Q'ld. Q.G.S. Pub. 92 (1892). F. W. Whitehouse, MS. list dated 24/6/29 (1929).
Lake's Creek	R.E.E. (in G.Q.S. Pub. 92 and G.S. Coll.). F.W.W. (Q.G.M.J. 1928, p. 441).
Stanwell	R.E.E. (in Q.G.S. Pub. 92 and G.S. Coll.). F.W.W. (Q.G.M.J. 1928, p. 441).
Spring Creek, Cania	R.E.E. (Q.G.S. Pub. 92, 1892).
Yarrol	R.E.E. (Q.G.S. Pub. 92, 1892). W. H. Rands (G.S. Pub. 21, 1885).
Silverspur	F.W.W., MSS. list (1929). L. C. Ball (Q.G.S. Pub. 264, 1918).
Cressbrook Creek	F.W.W., MSS. list (1929).
Condamine Block	Richards and Bryan (Proc. Roy. Soc. Q'ld., vol. 36, p. 100, 1924).

Notes on Table IV. (Gympie Formation).

The table apparently represents fossils from a considerable thickness of Upper Carboniferous strata. As listed there are few forms in common between Stanwell (Neerkol) and the other localities. This is held to be due to the fact that the great majority are from a low horizon in the Neerkol Series and that the other localities probably represent considerably higher horizons in the Monkland Series. The only forms common to the above two series, as listed, are *Protoretepora*, *Rhombopora laxa*, *Polypora* (*?*) *smithii*, and perhaps *Stenopora*. An even greater difference exists between the lists of the Neerkol and the Rockhampton Series. This serves to show the isolation of the *Pustula* horizon of the basal Neerkol beds in comparison with the faunas of the Carboniferous sequence and collections from further zones are greatly needed, particularly from the topmost beds some 4,000 ft. higher for it seems reasonable to expect evolution towards more typical Permo-Carboniferous forms. The one important faunal link at present appears to be the zones with abundant *Protoretepora*, which seems to be identical or closely related to the Gympie and Bowen species.

This genus ranges from near the base of the series but it is not known in the Rockhampton Series. Many Permo-Carboniferous forms embellish the old records from Neerkol localities, but owing to many of them having been collected from creek boulders they have been omitted. The list is therefore greatly restricted and deemed unsatisfactory. It is quite certain that it cannot represent the entire fauna of the Neerkol Series, a serious omission for the purpose of correlation being the entire absence of any records of corals in it.

Corals again show the most marked evolution as a group and there is probably almost a complete change between those of the Lower and Upper Carboniferous Series *Trachypora wilkinsoni* and *Monilopora* appear characteristic of what are probably the later stages of the Upper Carboniferous transition. *Stenopora* and *Protoretepora* make their first appearance in Queensland, the first possibly low down in the sequence at Stanwell in a form not yet described. Likewise *Strophalosia* makes its first appearance and the productid group appears to make immense advances in numbers and species ranging from extreme pauperitic types to the abnormal "*Productus* (*?*) *subquadratus*" of Lake's Creek. Permo-Carboniferous types of *Spirifers* and pelecypods probably develop in a marked manner towards closing stages under possibly glacial or interglacia climatic conditions but are strongly intermingled with the Carboniferous pauperitic types.

IX.—THE PERMO-CARBONIFEROUS FORMATION.

The following general correlation of the Permo-Carboniferous systems of the Bowen River, Queensland, and the Hunter River, New South Wales, is that at present recognised by the Queensland Geological Survey:—

Upper Bowen	.. ..	Newcastle to Tomago
Middle Bowen	Marine Series ..	Upper Marine Series
	Collinsville Coal Measures	Greta Coal Measures
Lower Bowen	.. ..	Lower Marine

With regard to the development of the Bowen Formations in the Great Syncline of Queensland, it must be stated at the outset that with the exception of the Collinsville district the survey work is only of a reconnaissance nature, and therefore anything like final deductions can scarcely yet be admitted on several questions of correlation and the positions of many faunal horizons.

Lower Bowen Series.

Jack[107] in 1878 instituted the term to cover sandstones interbedded with lavas, tuffs, and conglomerates lying conformably under the Middle Series. These sandstones are now known as the Lower or Mount Devlin Coal Measures. The writer in 1924[108] extended the term to include the associated volcanics on the evidence of further sediments interbedded with them and the first discovery of *Glossopteris* therein. The term comprises also extensive deposits of marine sediments in other districts, notably Springsure, the Upper Dawson, Yatton, the Styx River, &c.

This series in the northern portion of the Great Syncline is largely composed of fragmental volcanic rocks and lava flows, variously ranging from ultrabasic to acid types, but in some districts there are important thicknesses of true sediments included in them as in the Mount Devlin Coal Measures of the Collinsville field and, apparently, as in the little-examined Mackay district. The sediments are often of freshwater origin, particularly in the northern areas, and there are thin bituminous coals

developed, as in the Mount Devlin and the Stuart Creek (Townsville) measures, and probably also in the Mackay beds. There is a considerable development of freshwater *Glossopteris* beds at Stanwell below the great mass of volcanic rocks (the Dinner Creek Series), and these can provisionally be placed in the Lower Bowen until its downward limit is officially decided. Indeed, there are very poor grounds for separation, as the sediments ascend gradually with alternations of volcanic rocks till the former cease almost entirely. But apart from this the writer now suggests that for freshwater sediments the presence of the *Glossopteris* flora might be considered as a ground for determining the downward limits of the series. The Lower Bowen optimum, for the present, may be provisionally considered at Stanwell as 5,500 ft. for volcanics, and 3,200 ft. for sediments and volcanics; total, 8,700 ft. At the Bowen River 5,400 ft. (?).

Marine sediments of the Bowen Series, which can at present be classified as of lower age than the Collinsville Coal Measures, are considered to extend as far north as Mount Britton, and possibly to Hazelwood Creek on the eastern side of the Bowen River field, and extend southward throughout the Great Syncline, notable localities known and collected from being Mount Britton, Cardowan (?), Mount Bora, Yatton, Cracow, and Springsure district (Dilly, &c.).

In the advance report of the Nebo district[109] the writer attributed the lowest Mount Britton beds (following Jack) to the base of the Middle Bowen, although at the same time it was stated that the noted fossil bed there did not appear on the Collinsville field, i.e., above the Middle Bowen Coal Measures. The grounds on which the Mount Britton basal horizon was not then attributed to the Lower Bowen, where it is now considered it should be placed, are as follows:—(1) It lies immediately above the highest volcanics of the Lower Bowen at that locality, and it was then considered that the topmost flows at Mount Britton were contemporaneous with those at Collinsville, and that the non-appearance of the marine horizon in question at the latter place was due to overlap of higher beds, similar in case to that of the Wall sandstone, thus implying a considerable non-sequence at Collinsville between Middle Bowen Coal Measures and the Marine Series. Subsequent work in the basin has shown that the topmost flows in different districts are frequently not contemporaneous, e.g., the Mount Devlin basalts do not appear on the Western Isaacs, and marine sediments appear to entirely replace volcanics in the Springsure Lower Bowen. (2) The Mount Britton bed has a faunal assemblage, elements of which are not known to occur *above* the coal measures where mapped, but which is more comparable to the Lower Bowen Series of Dilly, Yatton, and Cracow in the presence of such species as *Productus (?) subquadratus, Productus* sp. nov. (*"Anidanthus"*), and *Aviculopecten mitchelli.* (3) The published sketch section of Mount Britton[110] shows this bed considerably lower than the *Strophalosia-glacial* beds in that area as compared to the base of the coal measures at Collinsville in reference to the same beds. There is thus now considered a possibility of freshwater measures,

equivalent to Collinsville, occurring in the unknown portion of the section above the basal marine fossil bed of Mount Britton. (4) The Mount Britton form "*P. subquadratus*" occurs with the Lower Marine species *Eurydesma cordatum* at Rivertree[111] (N.S.W.) and Dilly (Queensland), and possibly also at Yatton and Cracow.

The geological examination of the Springsure district just completed has revealed the most complete section of the Lower Bowen yet recorded in Queensland. The total thickness of the section cannot be stated accurately, but is probably from 5,000 to 6,000 ft. thick, consisting of continually alternating marine and lacustrine deposits, with apparently a total absence of contemporaneous volcanic rocks in the region examined. As collections have been made of the marine fossil fauna from groups whose order of succession has been definitely established, it is possible for the first time in reference to this series to observe, to some degree, the evolutionary changes that have occurred in the life of the period. One of the striking discoveries is the abundant association of *Monilopora* and *Trachypora wilkinsoni* in an horizon about the middle of the series, and considerably below the marked *Eurydesma* horizon of the district. Combined with the record of the Middle Bowen for the Collinsville district, we have thus a fairly complete record through the Lower and Middle Bowen period.

Outside of the Great Syncline, marine horizons are known at the Styx (Wilangi, Tooloombah), and in the *Eurydesma* fault block correlated by Richards and Bryan with the Lower Marine (N.S.W.).

The Lower Bowen, as the Lower Marine, is characterised by the mollusc *Eurydesma cordatum* which is recorded from Yatton, Cracow, Dilly, Wilangi, and Silverwood, and appears up to the present to have a definite diagnostic value. It is recorded from the Kempsey (N.S.W.) marine beds, the age of which it is understood has not definitely been determined, and which it is suggested in this paper may range at least as low as the Gympie Goldfield horizon. *Productus* (?) *subquadratus* (Morr.) appears to be characteristic of the Lower Bowen in Queensland, with occurrences at Mount Britton, Dilly, Yatton (?), Cracow, and absent at Collinsville (Mid-Bowen) except for a reference by Etheridge Junr.[112] to a specimen from Pelican Creek, 2½ miles above Sonoma Road Crossing. Jack's map[113] of the Bowen field shows two road crossings going to Sonoma. If the higher one is referred to, the locality is thrown into the Lower Bowen volcanics; if the lower one is meant, it is probably at the base of the marine beds there, and thus there must be accounted a bare possibility of its ranging just above the Middle Bowen Coal Measures. Etheridge also records its occurrence at Lake's Creek. All the specimens figured by Etheridge[114] come from Mount Britton except one from Yatton. The New South Wales occurrences are Cessnock and Drake districts, these horizons being given as Lower Marine by Etheridge and Dun.[115] The Lake's Creek form has been neither figured nor described, and the writer refrains from accepting it as identical with the Mount

Britton and Yatton species until it has been so determined by detailed palaeontological examination and description. It is perhaps unique in size in Queensland *Producti*, and seems to attain a much larger size than the Lower Bowen forms. The former, if distinct, may prove to be restricted to some stage of the Gympie Series, for it is recorded from Lake's Creek and from Malchi Creek near Stanwell. The latter specimen was collected, possibly, from a creek boulder. A small undescribed *Productus* is very abundant and characteristic of the Lower Bowen horizons at Mount Bora, Yatton, &c., and is recorded also from Mount Britton, but does not range up to the Middle Bowen Series. It has been figured by Etheridge (Geol. and Pal. of Q'ld., pl. 44, fig. 13), according to Whitehouse,[116] who places it as "*Anidanthus*" sp. nov. *Monilopora* ranges up from Gympie into Lower Bowen (evidently with some different brachiopod associations), but appears to be much more characteristic of the former series. For the rest a typical marine Permo-Carboniferous fauna is present, the detailed list of which is tabulated herein.

The volcanic rocks are an important entity of Central Queensland stratigraphy and topography, for they form a large proportion of the coastal cordillera as well as of the ranges and divides further inland, and their distribution at the surface has evidently affected even the present drainage systems. The rocks consist of both lavas and fragmentals, and while those of andesitic affinities predominate (largely as porphyrites) they yet range from extremely acid to ultra-basic types. Rhyolites are particularly highly developed in the western Isaacs and Collinsville districts, with zeolitic basalts especially in the Mount Devlin Series in the latter district. It is suggested in this paper that the thickness to 2,500 ft. of volcanics at the top of the sections in several of Silverwood Block Faults, together with underlying paralic deposits, also belong to this series.

Marine sediments of this age are considered to extend northwards from Springsure and Cracow (Upper Dawson) districts to the south-eastern portion of the Bowen River Coalfield. In the northern and north-western portions (i.e., north of Peak Range to Collinsville) they have not been recognised as occurring. The prevailing sediments are light-coloured sandstones, the fossiliferous beds being both calcareous (tests) and ferruginous (casts), which normally weather with great rapidity, and this type is almost universal and characteristic for the Lower and Middle Bowen in the Great Syncline. An exception to this is the limestone belt of Yatton-Mount Bora, in which dark calcareous shales and limestones occur. This horizon (together with that at Mount Britton) has been stated by Whitehouse[117] to be the basal Middle Bowen, but this view is considered unacceptable by the writer on the basis of succession as established by his fieldwork, and would not appear to be supported by the presence of such forms as *Monilopora nicholsoni*, *Productus* (*?*) *subquadratus*, and *Eurydesma cordatum*. It seems almost certain that the first and last species mentioned do not range as high as the Mount Britton marine basal horizon, and *E. cordatum* is otherwise

LOWER BOWEN CORALS, *Trachypora wilkinsoni* (ETH. FIL.) AND *Monilopora nicholsoni* (ETH. FIL.).

confined entirely to the Lower Bowen and Lower Marine (N.S.W.). As perhaps indirectly assisting towards this correlation, it should in fairness be mentioned that the writer in his advance report,[118] after some comment as to its possible controversial position, placed the Yatton limestone beds in the top division of the Lower Bowen immediately underlying the Middle Bowen, for the reason that, although the beds contained volcanic flows, the great mass of volcanics there immediately underlaid the limestone and the volcanics were at that time considered generally contemporaneous with those on the Bowen River field, and as representing almost entirely the Lower Bowen Series.

All the field evidence subsequently obtained has weakened such a consideration, for the discovery since of massive andesitic lavas, &c., of Lower Carboniferous age,[119] as well as such in intermediate strata, shows that great care and discrimination must now be used in Central Queensland in distinguishing between those and the volcanics ranging upwards through the Gympie Series to the Lower Bowen. The subsequent work of the writer has shown, on the west side of the basin, that the Mount Devlin basaltic rocks do not appear from the Suttor south, and that in the Springsure district, in collaboration with Morton, it was found that the Lower Bowen beds, wherever examined, are not interbedded with volcanics, although Jensen[120] has stated to the contrary. All of which, in conjunction with the writer's statement[121] made in 1924 to the effect that lower horizons of marine strata made their appearance progressively southwards from Collinsville (due to overlap), indicate that it may now be considered as beyond doubt that the age of the volcanic rocks immediately underlying marine Permo-Carboniferous in the Great Syncline are not necessarily contemporaneous, and certainly prove that at Collinsville vulcanism persisted to a later time than in the more southerly portions of the basin.

The freshwater beds on the Bowen field interbedded with the volcanics consist of light-coloured and generally more or less indurated sandstones and conglomerates. Dark-coloured or black shales, frequently indurated, have been observed and are the usual type within the folded eastern belt of volcanics at various localities between Nebo and the Mackenzie River. They, in contradistinction to the almost universal type of marine sediments, somewhat resemble in colour and degree of induration the marine dark mudstones and shales of Stanwell, Gympie, &c., and in most cases have yielded elements of the *Glossopteris* flora, but not in the volcanic-shale series below the Yatton limestone, which has yielded nothing definite so far.

In distribution the Lower Bowens extend discontinuously at least from Townsville to the vicinity of the New South Wales border, always, of course, on the coastal side of the Great Artesian Basin. To the north of Townsville, Ball[122] has adduced reasons for considering that the Lower Bowen may be represented in the infaulted area at Mount Mulligan.

The extensive peripheral distribution of the series in the Great Syncline has raised it to a stratigraphical status of the first importance in Queensland. On the coastal side a considerable distribution of fresh-water strata and volcanics extends from about Proserpine to Stanwell, and farther south, with developments of interbedded marine strata known in the districts of St. Lawrence and the Styx. Near the New South Wales border are the marine sediments with *Eurydesma cordatum*, &c., of the Silverwood Block Series. In this area it is considered that the massive rhyolites, andesites, &c. (2,500 ft.), at the top of the Eight-mile Creek and Rhyolite Range sections, alone find their analogues in the volcanics of this series, for the Middle Bowen in Queensland appears singularly devoid of interbedded extrusive rocks. The underlying black *Glossopteris* shales and conglomerates of the Eight-mile Creek Block at Silverwood may be perhaps compared with the Dinner Creek Series at Stanwell. Possibly the highest Drake (N.S.W.) sections are equivalent to low-placed Lower Bowens of Queensland.

The Banana district, placed in the Middle Bowen by Jack, seems definitely Lower Bowen, in part, with records of *Spirifer latus*, *Monilopora*, &c.

TABLE V.

FOSSILS RECORDED FROM AREAS CORRELATED WITH THE **LOWER BOWEN** SERIES.

	Dilly and Springsure.	Yatton.	Saltbush Park (Basal Beds).	Mount Britton (Basal Beds).	Cracow.	Silverwood (Eurydesma Block).	Styx District (Tooloombah, Wilangi).
Plerophyllum gregoriana de Kon	x	x					
Plerophyllum sp.	x						
Trachypora wilkinsoni Eth. fil.	x	sp.					
Monilopora nicholsoni Eth. fil.	x	x					
Stenopora australis Nich. & Eth. fil.	x	..	..	..	..	sp.	
Stenopora gimpiensis Eth. fil.	x						
Stenopora ovata Lonsd.	x						
Stenopora crinita Lonsd.	x						
Tribrachyocrinus clarkei McCoy	..	..	..	x			
Platycrinus (?) *nux* Eth. fil.	..	..	..	x (f)			
Fenestella fossula Lonsd.	x	x	x	..	..	x	
Fenestella internata Lonsd.	x						
Fenestella cf. *cavea* Laseron	x	sp.	..	sp.			
Polypora pertinax Laseron	..	sp.	x cf.				
Protoretepora ampla Lonsd.	x						
Protoretepora woodsi Eth. fil.	x						
Rhombopora (?) *laxa* Eth. fil.	x						
Chonetes cracowensis Eth.	..	..	..	sp (f)	x	sp.	
Strophalosia clarkei Eth.	x	sp.	..	..	..	..	sp.
Strophalosia cf. *jukesi* Eth. fil.	x						
Productus farleyensis Eth. & Dun.	x	..	..	x	..	x cf.	
Productus brachythærus G. Sby.	x	..	..	x	..	..	x (p)
Productus elongatum Eth. fil. & Dun	x						
Productus cf. *tenuistriatus* Vern.	..	..	..	x			
Productus (?) *subquadratus* Morr.	x	x	..	x (f)	x	..	x (p)
Productus ("*Anidanthus*") sp. nov.	x	x	x	x			
Dielasma cymbæformis Morr.	..	..	..	..	..	x	
Dielasma cf. *hastata* Sow.	x						
Spirifer duodecimcostatus McCoy	x	..	..	x (f)			
Spirifer strzelecki de Kon	..	..	..	..	..	..	x (p)
Spirifer latus McCoy	..	x					
Spirifer stokesii Konig	..	x (f)	..	x			
Spirifer aff. *tasmaniensis* Morr.	x						
Spirifer aff. *byroensis* Glauert	x						
Spirifer spp. ind.	x	..	..	x (f)			
Martiniopsis subradiata Morr.	x	..	..	x	..	sp.	

FOSSILS RECORDED FROM AREAS CORRELATED WITH THE **LOWER BOWEN** SERIES—*continued.*

	Dilly and Springsure.	Yatton.	Saltbush Park (Basal Beds).	Mount Britton (Basal Beds).	Cracow.	Silverwood (Eurydesma Block).	Styx District (Tooloombah, Wilangi).
Martiniopsis cf. *subradiata* Morr	..	x	..	x			
Martiniopsis branxtonensis Eth. fil.	..	..	..	..	..	..	x
Martiniopsis oviformis McCoy	..	..	..	..	..	..	x cf.
Martiniopsis darwinii Morr.	..	x (f)	..	x			
Martiniopsis (?) sp. nov.	..	..	..	..	x		
Aviculopecten cf. *gracilis* Fletcher	x						
Aviculopecten tenuicollis Dana	..	..	..	x	..	sp.	
Aviculopecten mitchelli Eth. fil. & Dun	(?)	..	..	x			
Aviculopecten squamuliferus Morr.	..	..	..	..	..	..	x (p)
Aviculopecten engelhardti Eth. fil. & Dun	..	x cf.	..				
Deltopecten illawarrensis Morris	..	..	..	x (f)			
Deltopecten limæformis Morris	..	..	..	x (f)	..	..	x (p)
Deltopecten comptus Dana	x						
Pecten (*Syncyclonema*) cf. *aviculatus* Swallow	..	..	x				
Eurydesma cordatum Morris	x	x	..	..	x	x (f)	x
Eurydesma hobartense Johnston	x						
Eurydesma sp. nov.	x						
Cardiomorpha cf. *gryphioides*	..	..	..	..	..	x (f)	
Edmondia sp.	..	..	..	..	..	x	
Chænomya etheridgei de Kon	..	..	..	..	..	x	
Mæonia carinata Dana	..	..	..	..	..	x	
Mæonia elongata Dana	..	..	..	..	..	x	
Mæonia minor Eth. fil.	..	..	..	x			
Cleobis sp.	..	..	..	..	..	x	
Pleuropherus sp.	..	..	..	..	..	x	
Stutchburia costata Morris	..	..	..	..	..	x	
Astartila sp.	x	..	x				
Nuculana sp.	x						
Modiomorpha mytiliformis Eth. fil.	..	..	..	x			
Ptychomphalina sp.	x						
Platyschisma rotunda Eth.	..	..	..	..	x (f)		
Platyschisma oculus Sby.	x cf.						
Pleurotomaria sp.	..	..	..	..	..	..	x (p)
Bellerophon (*Warthia*) *micromphalus* Morr.	x						
Orthoceras	..	..	x				
Girtyites (?) sp.	..	..	..	x			
Flora : *Glossopteris, Gangamopteris, &c.*		..					

x Indicates the particular species (with qualifications indicated), but sp. in locality columns indicates occurrence of genus only (species not determined) ; (p) provisional determination ; (f) specimen figured, refer to references below.

REFERENCES FOR LOWER BOWEN FAUNAL LISTS.

Dilly and Springsure .. R. E. Etheridge, Junr., cited Q.G.S. Pub. 277, p. 174 ; and F. W. Whitehouse (H. I. Jensen Coll.). List dated 24/6/29, and Q'ld. Min. Jour. 1930.

Yatton .. .. .. R.E.E., Junr. (G. and P. of Q'ld.), F.W.W. (Q.G.M.J. 1925, p. 474).

Saltbush Park (basal) and Mount Britton (basal) F.W.W. (Q.G.M.J. 1925, p. 474); R.E.E., (G. and P. Q'ld.) ; R.E.E. and W. S. Dun, N.S.W. Pal., Mem. No. 5, p. 22, pls. 10/11.

Cracow .. .. R. Etheridge, Senr., Q.J.G.S., vol. 33 (1872). Q.G.S. Coll., det. F.W.W.

Silverwood .. .. Richards and Bryan's List for Eurydesma Block (Proc. Roy. Soc. Q., vol. 36, p. 100, 1924).

Styx District .. .. F.W.W. (Q.G.S. Pub. 276, p. 96) ; R.E.E. (for *E. cordata*—N.S.W., Pal. Mem. No. 5, p. 73).

Notes on Table V. (Lower Bowen).

The corals as listed show no change in genera from those of the Gympie (Monkland Series) of the Upper Carboniferous group in the accompanying tables, but there is probably a decline in development nevertheless. *Pleurophyllum* continues through to the Middle Bowen and is very abundant in the top glacial bed of the Dilly group, while *Trachypora wilkinsoni* and *Monilopora nicholsoni* definitely ascend to approximately mid-horizons in the Lower Bowen Series. There seem to be some reasons for considering as doubtful whether the Yatton Limestone will eventually remain in the Lower Bowen and not have to pass down to the Gympie Series. These reasons are the change of the beds to the "Carboniferous" lithological type, the suggestion of a more pauperitic fauna, and the fact that *Glossopteris* has not yet been recorded from the black shales in the volcanics immediately underlying the limestone. Yet the present difficulty obtrudes of where to draw a division line between Gympie and Lower Bowen Marine beds, owing to their apparent general conformability, should a sequence be found.

There is a marked development of *Stenopora* and the Gympie species (*S. gimpiensis*) would fall out were it not for one record at Dilly. *Chonetes cracowensis*, a survival, on the records, from the Lower Star beds, makes its last appearance at Cracow. The first definite appearance of *Strophalosia clarkei*, shortly to be paramount in the Middle Bowen, is recorded. The productid group shows rapid strides to generally larger forms, with at least one exception, but declines possibly in species. Morris' species of *Productus* (?) *subquadratus* is present almost everywhere and may yet prove diagnostic for the Lower Bowen. *P. brachythœrus* is present and "*Anidanthus*," as recorded by Whitehouse, ranges to what must be nearly the top of the series at Mount Britton (basal beds) but passes no higher according to the records. The *Spirifers* call for little comment but some members of the *Martiniopsis* group become larger, more abundant, and diverse than in the Gympie Series.

The pelecypods make a subordinate showing except for *Eurydesma* and *Aviculopecten*, and this is possibly due to the limestone facies of several fossil horizons and lack of collecting at Cracow, Styx, and Saltbush Park, as well, perhaps, as to the fact that in the Springsure district, where the Lower Marine beds appear best developed, they are partly obliterated by large tracts of Tertiary basalts, &c. The "Eurydesma Block," Silverwood, redeems the group from very minor representation. *Eurydesma cordatum* is characteristic and, so far, diagnostic for the series. The Dilly glacial bed is its most remarkable known horizon as it occurs in layers in great numbers associated with a new and undescribed species.

The Middle Bowen Series.

(*a*) *Collinsville Coal Measures* (= *Greta or Lower Coal Measures*). —Occur at Collinsville at the base of the Marine Series. Thickness 700 ft. of coarse siliceous sandstones and shales with five coal-seams ranging individually from 4 ft. to 23 ft. and together aggregating an average thickness of 48 ft. in the type district. A marine horizon occurs within it and has been identified at the surface and in several bores; in one of the latter it proved to be 25 ft. thick and contained fragments of marine shells, its position being 200 ft. below the terminal beds. Its fauna has not been determined. The lower 100 ft. of the measures consists of conglomerate of decomposed and reworked volcanics of the lower series, suggesting a slight break at the base. The recorded flora consists of *Glossopteris indica, G. ampla, G. Jonesi,* and *Nummulospermum bowenense.*

These measures have been traced at wide intervals down to the Peak Downs district on the western side of the Great Syncline, and at Rugby Bore, Grosvenor Downs (Denham Range), the log indicated a thickness of about 30 ft. of bituminous coal at a depth of 440 ft., the measures being obscured at the surface. On the eastern side no evidence has been discovered of these measures south of the Bowen River. They, or their equivalents if marine, are expected to lie between the basal marine bed and the (?) Wall sandstone at Mount Britton, and south of these they are (if present) evidently effectively hidden by the basalts, alluvial and densely brigalow-covered soil flats of the Nebo Creek and Isaacs River valleys. In the Springsure district these coal measures do not appear to be well developed. On the coastal areas the Black Rock Creek measures (Mackay district) with *Glossopteris* spp. and *Vertebraria* are considered equivalent to Middle Bowen measures. They are 1,100 ft.

(?) thick and contain at least six seams ranging up to 20 ft. thick individually, and aggregate from 50 to 60 ft. of coal. The correlation is strengthened by the fact that very little coal has yet been found anywhere in the Lower Bowen, so that such great thicknesses are scarcely expected as low. The work of Cameron[123] suggests that these measures are the highest Permo-Carboniferous beds present in the Mackay district north of the Pioneer River. South of the river it is thought, though the evidence is yet meagre, that we must look for lower horizons. The known development of these valuable coal measures is therefore quite restricted in Queensland in comparison with the very wide distribution of the Bowen Series. All the Bowen formations alike in the Great Syncline pass southwards beneath an unconformable cover of Mesozoic sandstones, &c., in the Upper Dawson district, and there is apparently no reason why the coal measures may not be more or less continuous under the Mesozoics down to northern New South Wales considering the presence of Permo-Carboniferous measures at Ashford, &c.

(*b*) *Marine Series.*—This is likewise best known in the Bowen River field of which the Collinsville area is the only one surveyed in detail. It consists essentially of soft sandstones, often calcareous and ferruginous, weathering easily and producing little relief except the basal "Wall" sandstones of siliceous type about the Bowen River. It is particularly noteworthy in two respects—its great wealth of marine fossils and the conspicuous evidence of glaciation in the form of dropped ice-borne *débris* consisting of a multitude of pebbles, boulders, and occasionally large blocks (up to one ton). No volcanic flows are known in this series or the preceding measures, and the Middle Bowen appears as a period of volcanic desuetude following the violent and widespread outbursts of the Lower Bowen which apparently realised in Queensland the climax of Upper Palæozoic volcanic activity. The fauna is a typical Upper Marine (Permo-Carboniferous) one, but many new undescribed species and several new genera have been found in Queensland. *Strophalosia clarkei* is the dominant species in numbers (perhaps next followed by *Productus brachythærus*) and ranges throughout the series. Its numerous development in the lower zones is one of the great features of the Middle Bowen. In addition there is a very rich pelecypod fauna (*Chænomya, Maonia, Cleobis, Merismopteria,* &c.), and the common gasteropod *Bellerophon* (*Warthia*) *micromphalus* is exceedingly abundant. Corals are not frequently recorded and could not at any rate have been well represented with the exception of *Pleurophyllum gregorianum* which is known to be abundant in one bed at Logan Downs.

This marine series has been definitely traced around the northern portion of the Great Syncline from Mount Britton to Logan Downs (Clermont district), in both of which places the palæontological and glacial data are tied to that of Collinsville. From the Quarry Hill shaft at Clermont a collection of fossils has been recorded by Dunstan from beds which are considered to belong to the series. On the eastern side,

Productus (?) *subquadratus* (Morr.), from the Lower Bowen of Mount Britton and Cracow.
(All ½ nat. size.)

south of Mount Britton, the higher marine beds become increasingly obscured, but the series has been, on reconnaissance work, extended south to the Mackenzie River (Chine Bluff) on the evidence of sandstones of marine facies with occasional marine fossils. South of this locality, the Middle as well as Lower Bowens appear to be entirely obscured under Tertiaries[124] for 50 miles, but marine beds have been traced down the Upper Dawson by Dunstan[125] to Kianga Creek and by Jensen and Dunlop[126] to Cracow. Certainly, Lower as well as Middle Bowen Marine beds are represented in these (*E. cordatum* at Cracow), though their division line has yet to be defined, for since 1928 it has been definitely clear from the Springsure[127] section that marine deposition was going on in the south-western portion of the syncline contemporaneously with the Lower Bowen vulcanicity of the Bowen River basin.

Outside of the Great Syncline the marine beds of Mount Brunswick (Styx district) have been provisionally assigned by the writer[128] to this series on account of fossiliferous sandstones and shales (with *Mourlonia*, *Aphanaia*, &c.) of identical Collinsville types, possibly lying about 6,000 ft. above the topmost volcanics of the Lower Bowen. This appears to be the only recorded occurrence of possible Middle Bowen marine sandstones on the coastal belt.

Whether any of the freshwater strata of the wide Permo-Carboniferous belt fringing the Great Artesian Basin belong to this period is not known. The work of the writer in the region of Clermont[129] indicates that the marine beds there were close to an older Palæozoic continent, and that the transgression of the Middle Bowen epeirie sea was nearly approaching its most westerly limit. There is a marked transition series between the Middle and Upper Bowen in the Cherwell Range district, north of Clermont. The most westerly collection of marine fossils is reported from near Mantuan Downs,[130] about 75 miles W.S.W. of Springsure, but the occurrence has not actually been investigated by a geologist nor is the locality stated with exactitude. It can be, however, little west of the longitude of Clermont (Quarry Hill).

Reference to the Middle Bowen would be incomplete without noting the curious "rootlet" beds,[131] first mentioned by Jack, giving rise to the pseudo-perforated sandstones, notably in the Cherwell Range district. They are abundant throughout the marine series and usually, if not wholly, in layers that do not contain marine fossils. They have been observed also in the lower sections of the Lower Bowen of the Springsure district. The field evidence points to estuarine conditions (for the "rootlet" layers) sandwiched with true marine conditions, and their great, if not entire, development is on the western side of the syncline and in the Collinsville district. Their interest lies partially in the fact that no other formations in Queensland appear to have been recorded as having these forms, as well as in their unknown origin.

TABLE VI.

FOSSILS RECORDED FROM AREAS CORRELATED WITH THE **MIDDLE BOWEN** SERIES.

	Bowen River Coalfield.	Mount Britton (Upper Beds).	Saltbush Park.	Springsure.	Logan Downs.	Grosvenor Downs.	Eaglefield.
"Zaphrentis" profundus Eth. fil.	..	..	..	x			
Pleurophyllum gregorianum	..	..	..	x cf	x		
Pleurophyllum (?) sp. ind.	x						
Stenopora crinita Lonsd.	x cf.	..	..	..	x		
Stenopora ovata Lonsd.	x	..	..	x			
Stenopora australis Nich. and Eth. fil.	x (f)						
Stenopora leichhardti Eth.	x (f)						
Stenopora jackii Eth.	x (f)						
Tribrachyocrinus corrugatus Ratte	x						
Furcaster sp. nov.	x (?)						
Fenestella carea Laseron	..	x					
Fenestella fossula Lonsd.	x (f)	x	x	x	..	x	x
Fenstella internata Lonsd.	..	..	x cf.				
Fenestella sp. nov.	..	..	x				
Polypora pertinax Laseron	..	..	x				
Polypora sp. nov.	..	..	x				
Protoretepora woodsi Eth. fil.	x (f)	x					
Protoretepora ampla var. *Koninckii*	x						
Phyllopora sp. nov.	..	..	..	x			
Derbyia senilis Phill.	x (f)						
"Orthotetes" (gen. nov.) sp. nov.	..	..	..	..	..	x	
Strophalosia clarkei Eth.	x (f)	x	..	x	x	..	x cf.
Strophalosia gerardi King	x (f)						
Strophalosia cf. *jukesi* Eth. fil.	..	..	..	x			
Strophalosia sp. (large form)	x	..	..	..	sp.		
Productus brachythærus G. B. Sby.	x (f)	x	..	x	x	x	x
Productus farleyensis Eth. fil. & Dun	x	..	..	..	..	x	
Productus solidus Eth. fil. & Dun	..	..	..	x			
Productus sp. nov.	x						
Dielasma cymbæformis Morr.	x (f)	..	..	var.			
Dielasma sacculus Martin. var.	x	..	..	..	x cf		
Dielasma hastata J. de C. Sby.	x	..	..	x cf.			
Dielasma sp. nov. (small form)	x						
Spiriferina sp. nov.	..	..	..	x			
Spirifer convolutus Phill.	x						
Spirifer sp. nov. (aff. *hardmani* Eth.)	..	..	..	x			
Spirifer vespertilio G. B. Sby.	var.						
Spirifer duodecimcostatus McCoy	x	..	..	..	..	..	x
Spirifer tasmaniensis Morr.	x (f)	..	..	x cf.			
Spirifer (?) *clarkei* de Kon	x (f)						
Martiniopsis subradiata G. B. Sby.	x (f)	..	..	x			
Martiniopsis darwinii Morr. sp.	x (f)						
Martiniopsis sp. nov.	..	..	..	x			
Martiniopsis sp. juv.	..	..	..	..	x		
Actinoconchus sp.	..	..	..	..	x		
Cleiothyris sp.	x						
Solemya edelfelti Eth. fil.	x (f)	..	..	..	..	..	x cf.
Solemya (?) sp. nov.	x						
Schizodus sp. nov.	..	..	..	..	x		
Conocardium sp.	..	..	..	..	x		
Chænomya Etheridgei de Kon	x	..	..	..	x		
Chænomya acuta Eth.	x						
Chænomya bowenensis Eth. fil.	x						
Chænomya sp. nov.	x						
Pachydomus	x (?)	..	..	..	x		
Cleobis grandis Dana	x	..	..	..	x		
Cleobis recta Eth. fil.	..	..	..	..	x		
Mæonia carinata Dana	x	..	..	x			
Mæonia recta Dana	x						
Mæonia minor Eth. fil.	x						
Mæonia sp. nov.	x						
Notomya	x (?)	..	..	..	x	x (?)	
Aviculopecten cf. *sprenti* Johnston	..	..	..	x			
Aviculopecten tenuicollis Dana	x						
Aviculopecten squamuliferus Morr.	x cf.						
Aviculopecten engelhardti Eth. fil. & Dun	x cf.						
Aviculopecten sp. ind.	..	..	..	x			
Deltopecten subquinquelineatus McCoy	x	..	..	..	x		
Deltopecten limæformis Morr.	x						
Deltopecten sp. nov. aff. *comptus* Dana	..	..	..	x			
Merismopteria macroptera Morris sp.	x	..	..	..	x aff		
Merismopteria spp. nov.	x	..	..	..	..	..	x

FOSSILS RECORDED FROM AREAS CORRELATED WITH THE **MIDDLE BOWEN** SERIES—*continued.*

	Bowen River Coalfield.	Mount Britton (Upper Beds).	Saltbush Park.	Springsure.	Logan Downs.	Grosvenor Downs.	Eaglefield.
Modiomorpha (?) *mytiliformis* Eth. fil.	x cf.						
Stutchburia cuneata Dana	x aff						
Stutchburia sp.	x						
Bakewellia sp. nov.	..	..	..	x			
Astartila cytherea Dana	x (f)						
Astartila cf. *transversa* Dana	x						
Astartila cf. *polita* Dana	x						
Posidoniella intumescens de Kon	x						
Plagiostoma aff. *deltoideum* Girty	x						
Pleurotomaria subcancellata	..	..	..	..	x		
Ptycomphalina cf. *morrisiana* McCoy	..	..	..	x	sp.	sp.	
Mourlonia strzeleckiana Morr.	x	x	..	..	x	..	sp.
Mourlonia sp. juv.	x	..	..	..	x		
Mourlonia sp. nov.	x						
**Bellerophon* (*Warthia*) *micromphalus* Morr.	x	..	..	..	x		
Naticopsis sp. nov.	x						
Platyceras sp. nov.	..	..	..	x			
Hyolithes sp. ind.	x						
Flora : *Glossopteris, Gangamopteris,* &c.							

x Indicates the particular species (with qualifications indicated) but sp. in locality columns indicate occurrence of genus only (species not determined) ; (f) specimen figured.

* See footnote by F. W. Whitehouse, Q.G.S. Pub. No. 276, p. 80.

REFERENCES TO MIDDLE BOWEN FAUNAL LISTS.

Bowen River Coalfield	R. E. Etheridge, Junr. (Geol. and Pal. of Q'ld., G.S.Q. Pub. No. 92) F. W. Whitehouse (Geol. of Bowen R. Coalfield, G.S.Q. Pub. No. 276).
Mount Britton & Saltbush Park ..	F. W. Whitehouse (Q.G.M. Jour. 1925, p. 474).
Springsure	F. W. Whitehouse (Q.G.M. Jour. 1930).
Logan Downs, Grosvenor Downs, Eaglefield	F. W. Whitehouse (Q.G.M. Jour. 1928, pp. 285-286).

Notes on Table VI. (Middle Bowen).

That this series shows 38 genera and about 80 species is due mainly to the fact that the Bowen River field at Collinsville, where it is so well developed, is the only Permo-Carboniferous area in the Great Syncline that has been surveyed in detail. It has also been extensively collected from. As compared with the Lower Bowen in the Great Syncline, corals have apparently become almost extinct. *Pleurophyllum* is the only genus on the records that definitely survives, and it is found abundantly in one *Strophalosia* horizon at Logan Downs. The typical Permo-Carboniferous fauna of the Hunter Basin (N.S.W.) appears extremely well developed with some exceptions. Outstanding features are the large forms attained generally, the extreme development numerically of *Stenopora* (5 species), *Strophalosia clarkei*, *Productus brachythærus*, *Dielasma* (4 species), *Merismopteria macroptera*, *Bellerophon* (*Warthia*) *micromphalus*, the giant form attained by *Cleobis grandis*, and the numbers and big range in species of pelecypoda. The genera *Chonetes* and *Platyschisma* are not at all yet represented. Compared with the Lower Bowen collections the following species (among others) appear on the present records to have not ascended :—*Stenopora gimpiensis*, *Rhombopora laxa*, *Chonetes cracowensis*, *Productus* (?) *subquadratus* (Morr.), "*Anidanthus*" sp. nov., *Spirifer stokesii*, *Aviculopecten mitchelli*, *Deltopecten illawarrensis*, *Cardiomorpha* (?) *gryphioides*, *Edmondia* sp., *Eurydesma cordatum*, *E. hobartense*, *Platyschisma* spp. A considerable number of new forms for the Permo-Carboniferous, involving both genera and species, have been recorded but are not yet described.

The Upper Bowen Series.

This consists in the Great Syncline of a thick series of freshwater sandstones (often tuffaceous) and shales, tuffs, and occasional thin basaltic lavas together with a marine horizon, first placed by Jack at an unknown position in it—the Havilah "Derbya" bed. The writer has also located a *Derbyia* sandstone bed near Jack's locality and indicated its probable position in the section on general grounds only. The series is estimated on a single traverse to be over 9,000 ft. thick on the eastern side of the Bowen Syncline. On the western side of the syncline, in the Isaacs River basin, the series would more probably approximate to 4,000 ft. It covers the largest area of any of the Bowen formations in the Great Syncline, being surrounded by the older marine series except on the southern termination where all become covered by Mesozoic formations. The formation continues around to the wide belt of Permo-Carboniferous rocks which skirt the Great Artesian Basin from north of Tambo to the Flinders River, and these are considered to form intake beds to the Artesian Basin in several districts. The rocks there differ considerably and are light-coloured conglomerates, sandstones, shales (with dark shales), and volcanic evidence is not known except for a negligible occurrence of a tuff at Betts Creek.[132] This western belt is probably to be ascribed mainly to the Upper Bowen on several grounds, of which the chief is that only slight local unconformities separate it from the overlying Mesozoics and that transition is present. In several sections, e.g. Oxley Creek,[133] there is not the slightest break with the sandstones of the (?) Carborough Series (Trias). Outside of the above two major areas there appears to be no other proved Upper Bowen in Queensland, but certain small areas in North Queensland have been assumed to probably be of that age, such as the *Glossopteris* beds of Taylor's "Carboniferous" Tableland. Fossil plants in the Great Syncline are most abundant numerically and the flora includes—

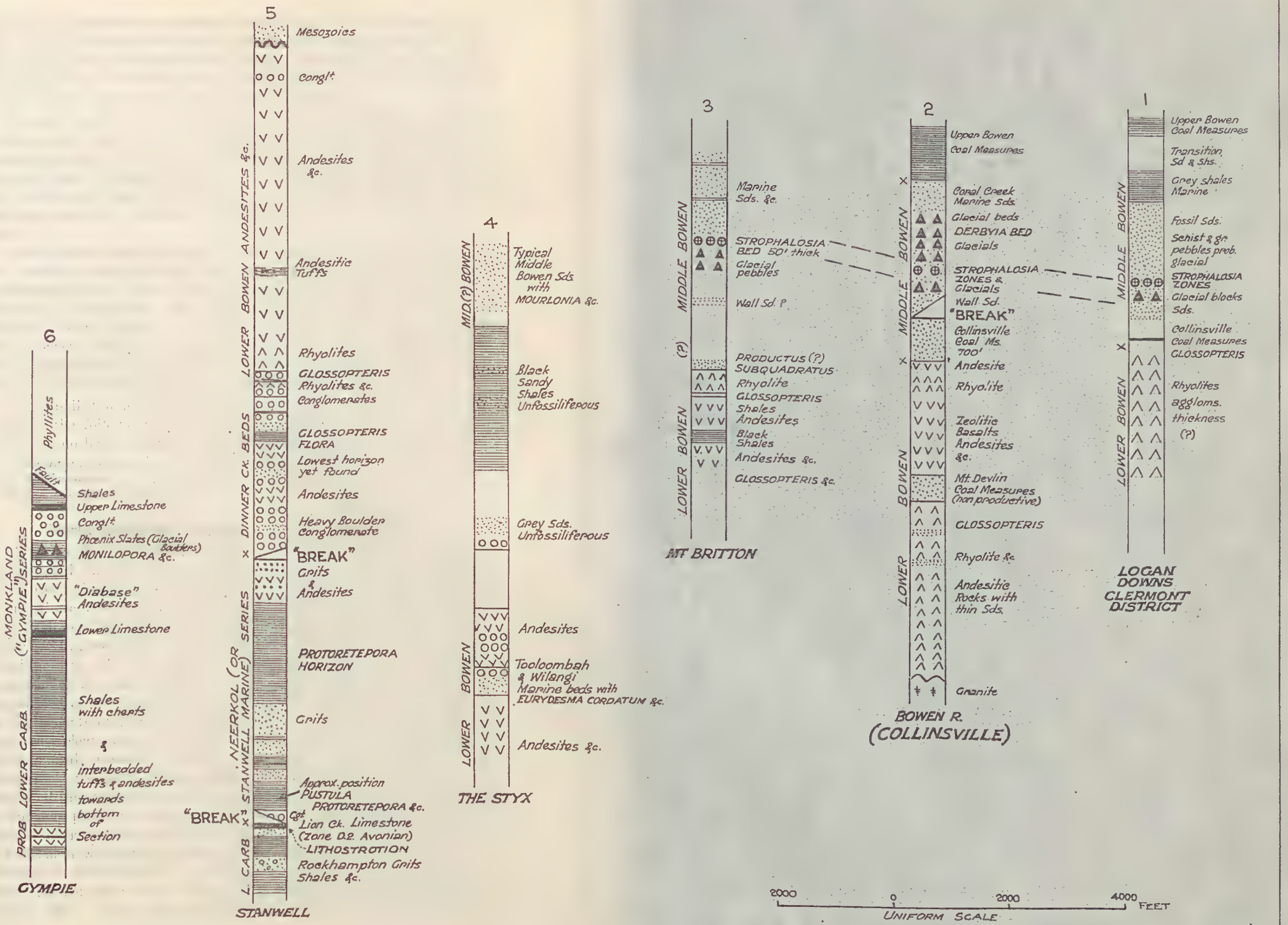
*Phyllotheca australis, P. robusta, *P.* sp., **Cladophlebis roylei, Sphenopteris polymorpha, S. lobifolia, *Glossopteris browniana, *G. indica, G. tortuosa, *G. ampla, G. augustifolia, *Vertebraria indica, Nummulospermum bowenense, *Gangomopteris cyclopteroides, *Nœggerathiopsis hislopi, Samaropsis dawsoni, Dictyopteridium sporiferum, Dadoxylon etheridgei, D. arberi.*

The above list is largely derived from Walkom's tables,[134] but is in accordance with the necessary transposition of many localities from the Lower to Upper Bowen horizons.[135] The species marked with an asterisk in the preceding list occur in the western basin, and in addition—

Sphenopteris sp. ind. cf. *lobifolia*, *Gangomopteris* cf. *augustifolia*, and *Samaropsis etheridgei* are also recorded.

Very notable fossil tree horizons are present throughout the length of the Great Syncline.

The series has undoubtedly important and almost unimpaired coal resources. Seams are worked on a small scale at Baralaba (six seams known in 600-ft. section, coal 9 ft., 8 ft., 6 ft., &c.), The Bluff (14-ft. seam



CERTAIN UPPER PALÆOZOIC SECTIONS IN QUEENSLAND

and others), Blackwater, and Blair Athol (seam to 93 ft. thick of clean coal). On the official, and much unofficial, data consisting of bore and well reports over a distance of 250 miles in the basin, colossal tonnages are thought by the writer to be a possibility of the future in an area of roughly 10,000 square miles (250 miles by 40 miles).

The coal within the zone of the late Permian folding is, as far as known, entirely semi-anthracitic (Baralaba to Bluff) and ranges down to bituminous in the more westerly unfolded areas of the syncline with one exception noted (Walker's Creek). In the western (artesian) beds at Betts Creek and Oxley Creek the coal is sub-hydrous like that of Blair Athol and also the Carnarvon and Consuelo coals of the Springsure district.

The upward terminal strata of the series pass frequently without any notable stratigraphical break into Lower Mesozoic sandstones (Carborough Series), but a marked unconformity exists on the Serocold anticline at Springsure and slight local unconformities have been observed at Betts Creek and near Oxley Creek. These relationships all occur, however, west of the highly folded Permo-Carboniferous strata where Ipswich beds, &c., lie with a marked angular and regional unconformity on Lower Bowens as at Stanwell, Warwick, &c.

The fossil fauna of the marine bed (Jack's "*Derbyia*" horizon) comprises the following (mostly provisional determinations) and seems to indicate no break whatever with the Middle Bowen fauna:—

Stenopora sp., *Derbyia senilis*, *Spirifer duodecimcostatus*, *S.* sp., *Productus brachythærus*, *Merismopteria* sp., *Aviculopecten* sp., *Mourlonia strzeleckiana*, *Bellerophon* (*Warthia*) *micromphalus*, *Goniatites* sp. ind.

North Queensland Volcanics, &c., of Doubtful Age.

A series of essentially acid volcanic rocks (porphyries, tuffs, &c.) is distributed far and wide over the eastern half of North Queensland beyond the latitude of Townsville. The localities where they have been remarked are Silver Valley (Herberton), Featherbed Ranges (Koorboora), Mount Mulligan, O.K. Mine (35 miles north of Mungana), Taylor's "Carboniferous Range," and the Newcastle Ranges on the Etheridge Mineral Field. In some cases intrusive porphyry is largely present as at Newcastle Ranges. These are probably all of one age on independent observations of Ball and Morton. No fossil evidence of their age has been found, but Ball considered that those at Mount Mulligan might be looked upon as forming a basal volcanic series to the Mount Mulligan coal measures containing *Glossopteris*, and pointed out that similar rocks nearer Koorboora contained thin seams of impure coal. He also stated that they are considered to be of Lower Permo-Carboniferous age but may possibly belong to the Carboniferous. Morton considers the volcanics overlying the Silver Valley *Aneimites* beds to be similar to those at Koorboora but cannot determine the question of conformability or otherwise at Silver Valley. It is obvious that the question of age for the group lies between Lower Bowen and Kuttung (N.S.W.) or revised Gympie (Q.). Their generally acidic character and stratigraphical

position has something to commend their provisional relegation to the Kuttung horizon, while on the other hand the fact that related dykes have burst through the *Aneimites* beds at Silver Valley and their underlying association with *Glossopteris* beds at Mount Mulligan and Taylor's "Carboniferous Range," 60 miles apart, suggest conformability with them and a possible Permo-Carboniferous age. If they are of Kuttung age the question of whether the Silver Valley *Aneimites* beds are folded with the Star at Hodgkinson is settled negatively at once, owing to their strong unconformity at Mount Mulligan with the latter. Although it seems unsafe to draw a definite deduction of absence of strong folding of later age than the sub-horizontal Silver Valley *Aneimites* beds, owing to the small area of the outlier there, it may be observed that in the Hodgkinson district it would almost certainly appear impossible to find an area of the Star Series of equal size in a sub-horizontal attitude.

The Drummond Movement in the Cairns hinterland therefore could be possibly of late Rockhampton age, and it would appear that the *Aneimites* beds may be angularly conformable with the volcanic series and the Permo-Carboniferous Coal Measures, as happens in the Hunter and Gloucester districts of New South Wales and in agreement with the Carboniferous and Permo-Carboniferous relationships in South-eastern Queensland. The Koorboora coal-seams with volcanic breccia dip towards the mountain cores at angles up to 30°, according to Jensen, who also states that the Permo-Carboniferous show no sign of folding. The evidence indicates that the volcanic series have not been more than very slightly folded, if at all, but disturbance by faulting is to be expected.*

In the western Isaacs the writer has described a series of fluidal rhyolites and agglomerates, in generally conformable attitude below the Middle Bowen Series, but in which no fossils were found. They were regarded as of Lower Bowen age and equivalent to the Mount Toussaint division of that series on the Bowen Coalfield. However, *Glossopteris* has been found only in the coal measures at the top of the Mount Toussaint rhyolites, &c., and there is no stratigraphical break at that horizon. Should these rhyolites in the Isaacs and Bowen coal basins ever be found to contain a *Rhacopteris* in *lieu* of a *Glossopteris* flora it would mean an entire Lower Bowen non-sequence in the western Isaacs and angular conformability between Carboniferous and Permo-Carboniferous in both basins. Such a discovery does not seem probable.

X.—EARTH MOVEMENTS AND RELATIONSHIPS.

An exhaustive study of Earth Movements in Queensland was made as late as 1925 by Bryan.[136] The movements of the Middle to Upper Palæozoic period as interpreted in this paper vary in a marked degree from the conclusions then reached, obviously to a certain degree because

* *References :* L. C. Ball, Q.G.S. Pub. Nos. 237 et 248 ; H. I. Jensen, ibid. No. 274.

rather extensive and very critical data have come to hand in the intervening four years. One has simply to consider the recent discovery of the true age of the Star Series—now down to Upper or even Middle Devonian—and its bearing on the formerly stated relationships of the Burdekin and Dotswood beds, to grasp the destructive effects on earlier analyses, involving time periods, based on previously established but incorrect ages of particular geological formations. The conclusions reached herein are that between the base of the Devonian system and the end of the Permian there have been almost certainly three, and not more, effective folding movements in the eastern half of the State. Their study has revealed the importance of *differential areas* of diastrophism and the *general sub-parallelism* of all their trends to the present coast—i.e., about N.N.W. to S.S.E., with local flexing of the trends.

It being desirable to elucidate, if possible, the downward relationship of the lowest strata described in this paper—the Star Formation—intensive research of Queensland literature has produced evidence of a highly probable folding movement of great intensity and significance in the Burdekin River region between the Chillagoe (Silurian) and Burdekin (Middle Devonian) periods as stated in the immediately following paragraphs.

(?) Lower Devonian Folding Movement.—The correlation of the Broken River limestones with the Middle Devonian Burdekin limestones by Jack and Etheridge,[138] and the extreme folding of the former, would appear to support a strong *post-Middle Devonian* movement as they, in a thick series stated at 20,782 ft. by Jack, are folded vertically to steeply over a very large area in the Upper Burdekin district. As Bryan[139] pointed out, it is difficult to reconcile such steeply dipping strata from the Broken River and Kangaroo Hills areas with the moderately folded limestones of the type district. A critical analysis of all the literature indicates so much that is irreconcilable that the conclusion is reached that a further collection and re-examination of the Broken River fauna, in default of a field examination of the section involved, is necessary to clear the position. On Daintree's data,[140] the Broken River Devonian rocks are to be considered as nearly 23,000 ft. thick, average dip 60° for 5 miles across strike without repetition. Then Jack[141] and Maitland[142] described sections of evidently an identical and adjoining series which, placed together, cover a traverse in the Upper Burdekin and Broken Rivers of about 50 miles in length from east to west in which the whole series (thickness 20,782 ft., *Jack*) is almost vertically folded on a N.E. to S.W. axis and often contorted, whereas the Burdekin limestone of the type and adjacent district, in contiguous areas (thickness to 450 ft., *Jack*, at Burdekin River and 7,000 ft. at Fanning River, *Jack*) nearer the coast, are evidently uncontorted and in comparison only moderately to gently folded, usually on a N.W. to S.E. axis. Maitland placed, with hesitation, outliers of Star beds, gently folded, lying on the continuation of the uptilted Broken River beds. He stated that it was only their strong lithological resemblance to strata of Star age in other

areas that gave any clue to their geological position. Jack[143] discovered a series (the Dotswood) lying directly and, to all appearances, conformably on the Burdekin limestone of the Fanning River which later gave him the same fossil assemblage[144] as the Star beds as well as being identical with normal lithological Star types. Because of his later ascertained unconformability of small outliers of presumed Star (confirming Maitland and also Daintree's record of *Lepidodendron australe* from this locality) on the Broken River Series and their identity with the Dotswood beds—

> "Lying directly on and, to all appearances, conformable with the Middle Devonian Burdekin limestones."

Jack concluded that the Dotswood Star beds must also be unconformable with the Burdekin limestones at Dotswood, as elsewhere,[145] in spite of his previously asserted unbroken passage. His statement[146] that it is evident there can be no sequence or passage from the Middle Devonian (Burdekin) to the Carboniferous (Star) is obviously due to his belief at that time that the Star was of Permo-Carboniferous age and even younger than Gympie. As some of the Lower Star areas are certainly of Upper Devonian age, his Fanning River (Dotswood) section now appears explicable as a conformable sequence passing only from Middle to Upper Devonian with the strong probability, or almost certainty on the evidence as it stands, of the Broken River beds being older than the Burdekin Series and separated therefrom by an extreme angular unconformity. Jack[147] stated that the Middle Devonian of the Burdekin, Fanning, and Reid Rivers were lying unconformably on quartzites, slates, greywackes, and shales, all of which types are mentioned, with others, in his Broken River Series, so that the shales, &c., unconformably under the Burdekin may well equal the shales, &c., at Broken River. He thus later abandoned the first-stated conformity at the Fanning River for an unconformity in these *unusual* terms—

> "This is the second time that groups of strata separated by an unconformability have actually been found to contain the same assemblage of fossils . . . the other instance was the Dotswood and Star."[148]

In both the Star beds of the Broken River and Dotswood beds he recorded red shales and, of certain beds in them, compared their resemblance to the Lower Old Red of Perthshire.[149] Another section in Queensland gives red shales and sandstones which have been compared in colouration to Old Red Sandstone types, and that is in the lower portion of the Drummond Range section, which is rather evidently Upper Devonian in age by analogy, and by the occurrence of *L. australe* near Bogantungan. The comparison of the red beds is stressed because apparently no other formation in Queensland than the Lower Star is known to have anything approaching this cosmopolitan Upper Devonian character. Everything—lithology, fauna, structure—points to the Dotswood beds being the basal Star beds in that district, and that there is just a normal and conformable sequence from the Middle Devonian limestone of the Burdekin to the Lower Star (Upper Devonian) of the type districts and thence to the Upper Star (Lower Carboniferous).

Etheridge Senr.[150] first placed the Broken River Series containing *Favosites*, &c., as "undoubtedly Lower Devonian or Siluro-Devonian." It must, however, be remembered that afterwards Etheridge Junr.[151] placed the Broken River limestone fossils in the same division as the Burdekin limestone, presumably on the presence of *Heliolites porosa*, which is the only species recorded common to the two. Only five species are described by Etheridge Junr. from the Broken River, and but one of them (*H. porosa*) occurs in the Burdekin limestone (with 20 to 30 species). Of the other four species *Favosites gothlandica* is a Silurian as well as a Devonian species, *Heliolites daintreei* and *H. plasmoporoides* affinities both lie in the Silurian as pointed out by Etheridge, while *H. nicholsoni* was described as a minute new species. *Heliolites porosa* is, of course, essentially a Middle Devonian form, but it is noted that Jensen[152] reports it to occur in the Chillagoe Upper Silurian. From the other two genera from Broken River little help is derived, but it is noted that the *Stromatopora* from there is in so highly silicified a state that no satisfactory examination could be made, while those from the Burdekin Series at Reid River were "much more satisfactory and massive examples." *Amplexus* from the Broken River is not recorded from the Burdekin by Etheridge.

It is most regrettable from the point of view raised in this section of the present paper that Etheridge, in grouping the fossils from Arthur's Creek (Burdekin Downs) and Broken River together, has drawn some general conclusions as to their strong Devonian affinities from two forms particularly (*Aulopora repens* and *Trachypora meridionalis*) which occur in the former horizon and not in the latter, the former being part of the Burdekin limestone and distant about 80 miles easterly from the fossiliferous Broken River section described by Jack. The genera *Athyris* and *Cyathophyllum* are noted by Jack in his original section (1887) of the Broken River but passed over as corals and brachiopods (1892).

With so much conflicting evidence it is perhaps necessary to view the exact position of the horizon of the Broken River beds as non-proven, rather than to draw a deduction of great post-Middle Devonian orogeny in North Queensland (yet Morton's observations seem to favour this for the Hodgkinson district) but there seems an absolute weight of both structural and palæontological evidence in favour of a lower age than that of the Middle Devonian Burdekin limestone. The satisfactory determination of the faunal relationship of the Broken River limestones to that of the Burdekin limestone would possibly narrow down and exactly define the period of that elusive folding movement in North Queensland, the exact age of which has baffled so many investigators into the geological history of the northern parts of the State.

What is the age of those quartzites, slates, greywackes, and shales that Jack found lying unconformably under the limestones at the Burdekin? Skertchly describes quartzites, greywackes, and shales in beds regarded by both himself and Morton as the Chillagoe Series, and

they could possibly be of that age, yet Morton's observations in the Chillagoe-Hodgkinson district seem to render such a relationship improbable there.

That Silurian limestones occur in the supposed Devonian Broken River section is exceedingly probable from two separate references. Wm. Hann* in 1873 recorded that limestones near the present site of Mungana on the line of the Chillagoe limestones were similar in character to a like formation on the Broken River, and in 1928 Land Commissioner Ferguson (now of Emerald) verbally informed the writer that the limestone belt between the Broken River and Pandanus station had the identical and characteristic castellated appearance of some of the Chillagoe limestones.

At the Clarke River Telephone Station, Saint-Smith has informed the writer of an area of sandstone beds dipping regularly at angles of 10° to 15°, containing *Lepidodendron* (*L. australe?*). These lie between the districts where Jack and Maitland described regionally tilted beds (which include the Broken River section) unconformably lying under their Star beds. What is the explanation of all these isolated observations if not a remarkable angular unconformity between the Star and Burdekin on the one hand and Broken River beds on the other?

A geological examination of the Burdekin-Broken River districts certainly appears necessary for a correct interpretation of the North Queensland stratigraphical succession and relationships, and this area appears a critical one. It seems impossible on the conflicting records left us to form an assured and harmonious interpretation of the data from this region.

Middle Devonian to Late Lower Carboniferous.—With the former hiatus between the Burdekin and Star solved, following the establishment of Lower Star as an Upper (and perhaps down to Middle) Devonian horizon, it is apparent that there is a sequence unbroken by any folding between the base of the Burdekin and the top of the Upper Star at Drummond Range and Mount Wyatt. Throughout the coastal region from Broadsound southwards there must be many junctions of Devonian and Lower Carboniferous (Rockhampton), but apparently they have never been studied in detail and probably could not be readily recognised. Within the "Permian folded" area in the Upper Burnett the writer[153] has observed one large anticline marked on each limb by the *Lithostrotion* (D_2) limestone which goes down apparently to the Devonian in conformable sequence, for *Lepidodendron australe* was found at an interval below the limestone in which there was room for about 5,200 ft. of strata. The dips on either side of the fold are of the order of 35° to 60°, strike N.W., distance between horizon D_2-D_2, 6 miles. The comparative degree of alteration and general sympathy of attitude between the two have led to the opinion that they are not unconformably related, and an assumption to that effect for the Devonian-

* Northern Expedition of Mr. Wm. Hann, Parl. Paper 1873.

Carboniferous succession in all the coastal areas appears warranted by the above instance as well as by their relationship inland in Queensland and in North-eastern New South Wales, as described by Benson.[154]

Differential physical conditions arose about the Middle Carboniferous period, for on the coast the Rockhampton pass upwards through the Neerkol (Upper Carboniferous), and possible equivalents, to the Permo-Carboniferous without observed angular unconformity in both the Rockhampton and Mackay districts at least, whereas in the Central districts the sequence throughout the Drummond Range-Mount Wyatt area is broken, and there exists a marked and regional angular unconformity between the Upper Star and the Lower and Upper Bowens, which was recorded first by Jensen[155] and later supported by Morton and the writer.[156] The Drummond Movement is suggested for this approximate Middle Carboniferous diastrophism.

THE DRUMMOND MOVEMENT.

This may have originated in the later Lower Carboniferous for the exact positions of the horizons in the Drummond Range Star beds are unknown, but it is evident that it is essentially a Middle Carboniferous movement there—for it must correspond partly to what the writer considers the marine Gympie period, members of which are entirely missing westward of the Great Syncline.

In the Drummond Range folding was effected between *Lepidodendron veltheimianum* and *Glossopteris* (Lower Bowen) times, but it is not known definitely whether it pre- or post-dates the deposition of the Mount Mudge *Aneimites* beds, though it seems probable that it is later. From Ukalunda to Burdekin no *Aneimites* beds are recorded, and there it falls within the same limits as for the Drummond Range. In the Cairns hinterland it appears, on the available evidence, to have strongly folded the Lower Star of the Hodgkinson and to have pre-dated the deposition of the *Aneimites* beds of Silver Valley. According to Morton's observations already quoted and discussed, it may alone have folded the Chillagoe Series, but this must yet be considered doubtful pending further fieldwork. It appears to have considerably folded the Pascoe River beds.

For a distance of 250 miles, from Mount Wyatt to Springsure district, the Star beds are folded considerably on an axis which is nearly meridional but warps from N.W. to N.E. Dips of 25° to 40° are quite common, and, on their eastern boundary with the Anakie schists, Dunstan[157] shows Drummond basal conglomerates dipping up to 60°-70°. Throughout this length (adjacently) the Lower Bowens lie, in most cases, slightly dipping on a general N.N.W. strike. They and higher members of the Bowens completely overlap the Star Formation west of Springsure in making connection with the western Permo-Carboniferous basin, and appear similarly related on the Leichhardt Range north-east of Mount Wyatt. The structural features of the Drummond and Zamia Ranges have already been described. The Drummond movement affected a linear area of apparently great length;

its effects probably extended up to the Carboniferous beds of the Pascoe River, Cape York Peninsula, and in the geographical interval it appears to have moderately folded the Burdekin and Star beds north of Charters Towers and strongly folded the Hodgkinson beds between Cairns and the Palmer River as well as the Pascoe River beds. Easterly from the Drummond Range it must have had little extent and exerted no visible effect on our known coastal sections. Westerly there are obviously no means of gauging its extent in Queensland. In sum, then, it affected a known width of some 80 miles with possibility of extension westwards. It seems not improbable, considering its known length in Queensland, that it may have extended into New South Wales and affected (ultimately) stratigraphical relations in the more inland areas of the Carboniferous and Permian rocks where local unconformities have been observed.

This movement has not produced crushing or marked metamorphism (unless it be extremely local) in the Drummond, Ukalunda, Burdekin, and Hodgkinson areas; on this point there seems complete unanimity of opinion. Observe particularly the evidence presented herein regarding the Hodgkinson beds, which are indubitably the most highly folded and perhaps faulted area of Star known. It thus appears as a measured and almost thrustless movement in the Drummond Ranges compared with the late-Permian diastrophism, but its incidence was important, for it must clearly have been effective in producing a mountainous land barrier which confined the transgression of the Bowen epeiric seas within their known limits over a great part of Eastern Australia. It appears to delimit likewise, with one slight exception, the westward spread of Lower Bowen vulcanism.

LATE-PERMIAN FOLDING.

Queensland appears to have had a minor *rôle* in the Great Hercynian world-wide orogeny. The one now to be described is too belated to ascribe to an aftermath of that system, but must closely synchronise with the last Appalachian folding in North America. The late-Permian mountain-making movement in this State, resulting from tangential thrusts from the oceanic side (i.e., from N.E. to E.N.E.), affected the present coastal region, up to a maximum width of 160 miles, extending from about Cleveland Bay (Townsville) to the New South Wales border, a region for which an absence of noticeable folding movements is postulated from at least the later Devonian rocks up to the end of the Palæozoic period. There was, apparently, not a uniformity of either physical conditions or crustal stability, for after a lower and major period of marine sedimentation, which probably comprised the greater portion, or whole, of the Carboniferous period, oscillatory movements introduced alternating marine-freshwater (paralic) deposits characterised by widely distributed boulder-conglomerates with a great spread of lavas, followed by further subsidence and partial submersion under renewed marine conditions of a more marked littoral type during the Lower and Middle Bowen period.

The folding movement was of varying intensity, as areas, apparently limited, involved in it near the coast in parts of the Rockhampton

district and, particularly in the Mackay district, are not steeply folded. There was a marked tendency to overthrust westwards, and this seems greatest along the eastern edge of the Great Syncline from Collinsville southwards, for, at the former, thrust-faulting[158] occurs and severe accompanying compression is shown by the sharp elbow and hairpin beds of the formations with steep tilting. Also at Silverspur Ball[159] has described crushing and faulting that occurred in the "Permo-Carboniferous" rocks. It is noticed in Central Queensland particularly that the younger beds involved come in progressively westwards in a *general* manner (Devonian to Upper Bowen), and this thrusting from the coast (the evidence as to direction being decisive in the Great Syncline) evidently accounts for the marked absence of the younger beds nearer the coast, where they might have been more commonly expected to occur as synclinal relics according to the evidence of common folding, and their extreme development in the Great Syncline. Another explanation for this marked absence is, of course, that the later Bowen sediments were not deposited there.

Nothing younger than Middle Bowen (at Mount Brunswick and Black Rock Creek) is apparently accounted for to the east of the geanticline of Connors Range, &c.

The age of this intense movement is defined as during the late-Permian epoch by the participation of the highest Permian—the Upper Bowen—in it and by the strong and universal angular unconformity of Lower Mesozoic sandstones and coal measures on Bowen formations within the folded belt. The age of this movement was first thought by the writer to be possibly later than the Permian, on account of the conformable relationships of the Carborough (Trias) and Upper Bowen in the Great Syncline and the strong folding of the Cretaceous in the Burrum Coalfield. Such a view was seen to be impossible as late as 1928 when the Mesozoic rocks were studied in the folded area at Stanwell.

The area of strong folding was defined with singular emphasis at its western edge, for a concavo-convex line for 400 miles from Collinsville southwards (by east) marks narrowly its limit. Beyond that line, and extending as far west as the Serocold anticline, Springsure, the Upper Bowens are sub-horizontal or very gently undulating, so much so that massive Carborough sandstones have been observed resting on them with repeated conformity, on dips of 0-10°, and only very occasionally more. Recent work in the Springsure district has revealed a simple but marked anticline (first observed by Jensen) rising out of the sub-horizontal to gently undulating Bowen formations on its flanks, which is overlapped by the Mesozoic rocks (probably Upper Trias).

The Permian geomorphology of the Great Syncline suggests that the folding of the Bowen sandstones and shales corresponded with a compensatory gentle subsidence which permitted partly transitional and uninterrupted sedimentation, for a considerable distance to the west of this line, up to the Triassic. It is therefore thought that on these grounds the lower Carborough (Carborough = Hawkesbury ?) definitely

are older than the Ipswich and Stanwell coal measures, which were only deposited after the planing down of the folded late-Palæozoic rocks, and this view appears to touch vitally the question of past conflicting opinions amongst Australian geologists as to the relative age of the Ipswich and Clarence Series on the one hand to that of the Hawkesbury Series on the other. It is outside the scope of this paper and will perhaps be considered in a later paper.

The Ipswich are fixed as Upper Triassic by Walkom,[160] and for the Carborough the writer in 1928* expressed the following view:—

"They are considered to be probably contemporaneous in part with the Ipswich Series, but their general conformity with the Upper Bowen and aspect of continuous sequence over widely dispersed areas in Central Queensland suggest that they are partly lower and may in cases form transition beds from the Permian upwards."

Unfortunately the Carborough, as far as known, are practically devoid of recognisable fossil plants and there is no palæontological evidence of transition; for this it is necessary to go to the Sydney-Bulli region as stated by Dun.[161] The suite from Mount Mulligan, much resembling the Ipswich flora, comes from a bed of fossiliferous tuff at least several hundred feet above the base of the series which, according to Ball,[162] lies with a slight unconformity on the Permo-Carboniferous measures.

The Carborough sandstones are closely tied to the Hawkesbury sandstones (N.S.W.) in appearance, period, and may be identical. They seem to be totally confined to the west of the western limiting line of the strong Permian folding in Queensland and its possible prolongation into New South Wales, indicating that this mountain-making movement is probably genetically related to their subsequent deposition in inland lacustrine areas.

The folding of the Rockhampton-Dawson area does not permit correlation with the late Carboniferous folding of Western New England as described by Benson.[163] A marine geosyncline, which extended down to the border of New South Wales, is considered to have been in existence in coastal Queensland at that time. Its continuation into New South Wales during that stated period of folding might otherwise have been judged probable from the resemblance of the Upper Carboniferous rocks of the districts of Rockhampton, Gympie, &c., to those of Drake, Boorook, Vegetable Creek, and perhaps Kempsey, more so as comparatively recent work (Sussmilch, Browne and Dun, Osborne) has proved that there could have been no late-Carboniferous folding south from New England, in the Hunter Valley region. The line limiting strong late-Permian folding in Queensland appears to be in rather striking alignment with a line limiting strong late-Carboniferous folding, plotted from Benson's sections (though a big interval exists in which the Palæozoics are hidden), and in the evident absence of any unfolded Permian to the east of that line in New South Wales the writer is not convinced that they have no connection. Benson, however, with the

* Report of the Fifth Interstate Conference on Artesian Water, Sydney.

recent Queensland facts before him expresses belief in the late-Carboniferous folding for the western New England region.*

The stated unconformable relationships of the Carboniferous rocks and Permo-Carboniferous coal measures at Ashford (N.S.W.), as determined in the past, would appear to support Benson's belief and prevent any correlation, in time, of the folding movements if the former are established beyond dispute. But the evidence does not appear to harmonise. In 1893 David[164] made the statement that the Gympie Series of the Vegetable Creek district were strongly unconformable with the Permo-Carboniferous rocks at Fraser's Creek, near Ashford. Pittman[165] in 1896 described the unconformity between the Gympie (Carboniferous) and the Ashford Coal Measures with a map and section. Although he relied on details of opposing strikes and dips as evidence, they could apparently be equally due to severe faulting especially as the strikes plotted in the surrounding Gympie rocks are very variable. As to the sections shown (Pl. IV.) they might, on the Queensland evidence of infaulting of "Permo-Carboniferous" at Silverspur, possibly be considered due to similar action. If so, there still remains David's statement alluded to above, and in 1907 he published a section[166] showing the unconformable junction, and therein it is seen that both younger and older beds are highly disturbed and that the coal in the younger has become anthracitic as in the folded and faulted Upper Bowen at Baralaba, Dawson River. Later (in 1911) Carne[167] found a Permo-Carboniferous fossil collection in David's Vegetable Creek "Gympie" beds, and these are now shown on the New South Wales Geological Map as Lower Marine and divided from the unfossiliferous area of Carboniferous rocks around Ashford although David[168] had stated that the latter appear to be *conformable* with the Vegetable Creek beds, which would seem to be quite in harmony with Central Queensland evidence within the late-Permian folded area. Browne appears to disagree with Benson as to the late-Carboniferous folding, and says the circumstances would seem to point to a strong crustal deformation in late-Burindi time. Considering the divergent views that seem to exist in New South Wales on this important question, one is rather tempted to speculate as to whether Queensland conditions did not prevail there, and that perhaps no terrestrial Kuttung deposits exist in the Vegetable Creek area and that a Carboniferous marine sequence was deposited there with transition up to the Permo-Carboniferous; also as to whether there could not have been a possible misinterpretation of unconformability for faulting at Ashford and that all might have been highly folded, intruded, and faulted (blocks infaulted) in the late-Permian. Queensland evidence does not appear to lend any support to a late-Burindi folding (except in the Drummond Range region possibly) and there does seem some ground (see map at end) for considering the Ashford-Vegetable Creek districts as being possibly included within the coastal strip of Eastern Australia, so heavily folded in Queensland.

* Communication dated 9th May, 1929.

A striking analogy might even be hinted at between two far-distant areas both known generally to the writer, the Bowen River (Q.) and the Muswellbrook, Upper Hunter district (N.S.W.), in the latter of which Morrison[169] first proved that the Carboniferous are overthrust over the Permian on a fault line originally noted by Carne (the Hunter overthrust on which Osborne, Browne, and others subsequently made investigations). David had previously (1914) forecast overthrusting on this line when he stated that he considered the geo-syncline of the area, now known as the Main Coal Province, to be bounded on the north-east by a "heavy overthrust fault." This late- or post-Permian overthrust movement has left the Permians undisturbed in the near region to the west, and on these, at varying distances, the Hawkesbury Series lie without angular unconformity (see also Morrison and Jones's sections for Singleton and Wollar districts, respectively)[170] as the Carboroughs do on the Upper Bowen some 10 miles to the west of the folded and overthrust Bowen Series. The age of the Hunter overthrust is thought by Morrison[171] to be late-Permian (with further work necessary at Murrurundi to obtain definite evidence) while Osborne[172] has stated it to be post-Palæozoic but pre-Pliocene.

This important folding movement in Queensland was probably accompanied, or immediately succeeded, by widespread intrusions of granitic to basic magmas of which the former greatly predominated. Even the Upper Bowens are intruded by granite within the Great Syncline at Mount Flora copper mines. That they occurred at the same epoch as the great intrusions of the New England area, referred by Andrews[173] to the end of the Palæozoic to the Early Mesozoic period, cannot be doubted. Practically all the Permian-folded region is intensely intruded, as well by great and small areas of granite and other intrusions as by complex reticulations of a multiplicity of dykes, predominantly basic to andesitic. The Rockhampton-Stanwell district furnishes a leading example of both. These do not intrude the Stanwell Coal Measures (Mesozoic). After all this stress and consequent deformation we may then assume crustal relaxation, which was developed essentially by normal faulting as at Gympie and is probably general in the folded area.

Need we look further than the diastrophism and magmatic activity combined of the late-Permian for the origin of the important metalliferous deposits of the copper-gold province, which portion of the folded area represents, including Mount Morgan, Gympie, Mount Chalmers, Many Peaks, Mount Cannindah, Glassford Creek, and of the important tin province of Stanthorpe?

The late-Permian folding was, perhaps, finally responsible for the complete vanishing of the Palæozoic marine faunas and the absence of any Lower Mesozoic marine faunas in Eastern Australia.

XI.—QUEENSLAND LATE-PALÆOZOIC GLACIAL BEDS.

On the correlations advocated in this paper, three distinct glacial formations of different ages would appear to be established, viz., Gympie

(Upper Carboniferous), Lower Bowen (? Lower Permian), Middle Bowen (? Middle Permian), thus conforming more nearly to the New South Wales evidence of glacial periods ranging from the Upper Kuttung to the Upper Marine. At the outset it may be stated that no terrestrial glacial deposits have been satisfactorily demonstrated to exist in Queensland, and all are apparently the result of transported material from southern land areas. The freshwater beds in the Bowen Series appear quite free from glacial pebbles. They are spoken of as inter-glacial, but may merely signify—no land ice and means of transportation interrupted by temporary withdrawal of the sea.

(a) The Upper Carboniferous.—The first record of glacial boulders from the Gympie Series was that of Rands[174] in 1889 from the goldfield of that name. They consisted of isolated boulders or pebbles in the fine mud rocks of the Phœnix or Monkland shales. The largest isolated boulder measured 13 by 10 by 5 inches, and one boulder of granite about 6 inches in diameter was found enclosed in the O'Connell Reef. Rands said—

"The presence of such boulders in a rock that was laid down as a fine silt would point to the conclusion that they were dropped from floating ground ice."

Now that the field has been mapped in detail, it is shown that the nearest granite is 3½ miles away (Mothar Mountain), thus greatly enhancing the strength of Rands's conclusion. The evidence on the Gympie field is comparatively scant and suggests, perhaps, the penultimate or final residue derived from floe dispersion, and so is very different from that of the Middle Bowen in the Great Syncline. The glacial evidence has only been observed underground during mining operations. The horizon of the Monkland shale is near the top of the Middle Gympie division of Dunstan, and is a little younger than the fossil horizon 1 F.

At Silverspur the evidence seems unequivocally glacial, according to Skertchly,[175] who in 1897 noted fragments of granite in Gympie beds at the surface, and measured one partly buried granite block 7 ft. by 3·5 ft. by 2 ft., minimum weight a little over 2 tons. Ball[176] stated—

"A granite pebble was found in the ore between the 200 and 300 ft. levels. While many of the pebbles in the slate are due to movement and represent uncrushed country these granite pebbles . . . have been dropped from floating trees or ice during the deposition of the sediments."

Dunstan[177] has described large unbedded blocks of conglomerate in the Gympie Formation at Windah (Fitzroy River), but he has shown that these could be formed in other ways than by ice action. It is unlikely that they are true glacial boulders, such being normally composed of granite, porphyry, and schist in the Gympie and Bowen Series. These are the only records in the revised Gympie Formation which intervenes between the Lower Carboniferous and Lower Bowen volcanics.

(b) The Lower Bowen.—The best evidence in this series is seen in the Springsure district, where the section appears to be totally sedimentary with at least three marine stages, in the irregular distribution of variously smoothed and rounded pebbles of granite, &c., in the fine

sediments. Jensen[180] first noted this in the Dilly "limestone," and his conclusion for that horizon is accepted by Morton and the writer. His correlation of this horizon with Pelican Creek (Big *Strophalosia* bed) must be disagreed with on very strong palæontological evidence, Dilly being a noted horizon for *Eurydesma cordatum* and *Productus* (?) *subquadratus* (Morr.), both absent from Pelican Creek and all definite Middle Bowen horizons, as well as the marked diminution of *Strophalosia* at Dilly.

The recent survey in the Springsure district has shown only one marked glacial horizon, and this lies at the top of the Dilly marine stage. In it there is a most abundant distribution in fossil beds of dropped blocks and pebbles, of which the great bulk consist of schist, while the remainder are made up of granite, quartz-porphyry, and quartzite. Blocks up to 4 ft. by 3 ft. by 2 ft. were measured. A possible glacial horizon also occurs towards the base of the series.

(c) The Middle Bowen.—The evidence has been partly stated in the "Geology of the Bowen River Coalfield."[181] On that field it is the most significant evidence known in Queensland, and is widespread and arresting. It is at least evident over a thickness of about 1,000 ft., but probably over more than that. It was first noted by Jack[182] in 1879. Granite and schist blocks weighing up to one ton have been found embedded in the *Strophalosia* beds. Certain thin beds, as that directly on the *Derbyia senilis* horizon, almost resemble terrestrial tillites, but were evidently formed by a rain of transported *débris* ranging in size from "flour" to pebbles. The Collinsville *Strophalosia* stage, correlated with the Branxton glacials (Upper Marine), is the most noted glacial stage. It has been observed also at Mount Britton and Logan Downs (120 miles south of Collinsville) with similar, but less conspicuous, glacial evidence.

XII.—USE OF THE TERM PERMO-CARBONIFEROUS.

The writer suggests that, if the succession adopted in this paper is considered well founded, the time has arrived to consider the use of the term Permian instead of Permo-Carboniferous for the whole or part of the Bowen formations. This would largely be in keeping with the geological trend of the present day towards the elimination of hybrid nomenclature. One consideration regarding this question is that the glacial evidence of the revised Gympie Formation seems to fall nearer in line, chronologically, with Upper Carboniferous glaciation in New South Wales, South Africa, and India, as indicated by local authorities, although such an age is opposed by Schuchert,[183] who considers late-Palæozoic glaciation as all within the Permian.

Schuchert[184] (1928) stated that the Australian Permo-Carboniferous

> "is clearly a synonym for what is now elsewhere called the Permian system or Permian period."

This conclusion is developed chiefly from a world study of faunas and, in particular, of ammonoids where available. He also stated[185] that

"the Panjabian (*i.e. his Middle Permian, Salt Range, India*) ties directly into the Lower Marine Series of New South Wales."

This in turn ties largely into the Lower Bowen of Queensland. Wadia (1926) in his "Geology of India" placed the same Indian series in the Upper Carboniferous (p. 139), and also in the Permo-Carboniferous (p. 346). Cowper Reed[186] (1927) stated that the correlation of the *Productus* limestones (which immediately overlie the Panjabian) is not yet settled. Fox[187] (1928) tabulated the Speckled Sandstones, &c., of the Panjabian entirely in the Permian and the underlying glacial bed (Talchir) in the Upper Carboniferous, and this apparently represents the present official view accepted in the Geological Survey of India. All of which emphasises how divided opinions are as to the exact age of the supposed Indian equivalents of the Australian Permo-Carboniferous beds. Most recently Dighton Thomas[188] (1929), in reply to Schuchert, adduces new grounds for considering the first appearance of the *Glossopteris* flora to have been in the Uralian period (Upper Carboniferous). The recent discovery by the writer of beds containing the typical Carboniferous coral, *Monilopora nicholsoni*, at a higher horizon than the lowest *Glossopteris* beds in the Springsure Lower Bowen section appears to support this view.

In Australia, David[189] (1920) placed that portion of the New South Wales Lower Marine, ranging up to the special horizon of *Eurydesma cordatum*, as Uralian in age, while Whitehouse[190] (1928) disposed of the whole series entirely in a mid-section of the Upper Carboniferous. If, however, the latter's conclusions in placing it so low are influenced by Queensland evidence, the belief is maintained herein that most of the beds ascribed by him to the base of the Middle Bowen (i.e., Gympie, Lake's Creek, Condamine, &c.), and which would, consequently, be fairly well up in the Bowen Series, are *below* the Lower Bowen and in the Upper Carboniferous Transition Series to cover which Jack's Gympie Formation might be revised and determined as to provisional limits.

The New South Wales Geological Survey in recent years appears to have adopted the term Permian for what in Queensland is called Permo-Carboniferous at present. It seems very desirable that uniformity in nomenclature should be obtained for what are obviously stratigraphical formations common to the two States. Perhaps the Permo-Carboniferous can no longer be considered a distinct stratigraphical unit on account of the evidence herein as to transition.

On Queensland evidence, the following might form a basis of discussion towards securing uniformity with New South Wales:—

PERMIAN	Upper Bowen	Newcastle and Tomago
	Middle Bowen	Upper Marine and Greta
LOWER PERMIAN to LATE UPPER CARBONIFEROUS	Lower Bowen	Lower Marine
UPPER CARBONIFEROUS	Gympie Formation (Gympie beds, Lake's Creek beds, Neerkol beds)	Kuttung (in part)

If it should be found, as geological work progresses in the two States, that the interpretation herein of the higher Palæozoic succession is essentially correct and that more or less identical formations throughout the Carboniferous and Permian are shared by the States of New South Wales and Queensland, the work of both local and interstate correlations would be greatly facilitated by the interchange between the respective State authorities of duplicate material in the palæontological collections made from different horizons in these geological formations.

If, as the writer thinks possible, there are a number of localised non-sequences, particularly in the Carboniferous, such a course would probably enable complementary additions to be made to the faunal breaks in each State.

FINALE.

As the last proof of this paper went to press a belated collection of rocks from the Mount Mulligan sections of the Hodgkinson beds was received from Mr. A. Strang, colliery manager at Mount Mulligan, in pursuance of a request by the writer. They are highly seriticised and are considered by Mr. Morton to be identical with some members of the lower sedimentary beds of Silver Valley and of the Chillagoe limestone belt. This possibly throws the question of Middle Palæozoic orogeny in North Queensland into greater obscurity than ever and appears to favour the following interpretations:—

(1) The Drummond movement was *definitely* earlier in age than the Silver Valley *Aneimites* beds;

(2) The Drummond movement was alone responsible for a mutual folding of the Upper Silurian and Star beds in North Queensland, i.e., possibly no effective orogeny occurred there between Upper Silurian and late Lower Carboniferous.

The data in this paper in support of a doubtful Lower Devonian orogeny in North Queensland has been left in as a statement of the conflicting evidence in our literature and will perhaps be useful, as an analytical summary of the position, for pursuing further investigations into the problem.

XIII.—REFERENCES TO LITERATURE.

ABBREVIATIONS.

A.A.A.S.	Australasian Association for the Advancement of Science.
Geol. and Pal. Q.	Geology and Palæontology of Queensland, &c. (Jack and Etheridge 1892).
U. of Q'ld. ..	Department of Geology, University of Queensland.
G.R.N.D. ..	General Report upon the Northern District by R. Daintree, Parlt. Paper 1870.
R.S. Vic. P. ..	Proceedings of the Royal Society of Victoria.
P.R.S. Q... ..	Proceedings of the Royal Society of Queensland.
P.R.S. N.S.W. ..	Proceedings of the Royal Society of New South Wales.
P.L.S. N.S.W. ..	Proceedings of the Linnean Society of New South Wales.
Q.G.M.J. ..	Queensland Government Mining Journal.
Q.S.G. Pub. ..	Queensland Geological Survey Publication.
Handbook Q.G.	Handbook of Queensland Geology (R.L. Jack).
Rec. N.S.W. G.S.	Records of the New South Wales Geological Survey.
Geog. of Q.	Appendix B, Harrap's School Geography of Queensland.
M.R. N.S.W. ..	Mineral Resources Series of New South Wales.
A.R.M.D. ..	Annual Report, Mines Department.
Mem. N.S.W. G.S.	Memoirs of the New South Wales Geological Survey.
Bull. G.S.A. ..	Bulletin of the Geological Society of America.
Bull. W.A. G.S. ..	Bulletin of the Western Australia Geological Survey.
Rec. A.M. ..	Records of the Australian Museum, Sydney.
Q.J.G.S.	Quarterly Journal of the Geological Society.
Mem. G.S.I. ..	Memoirs of the Geological Survey of India.
Rec. G.S.I. ..	Records of the Geological Survey of India.

1.—Geol. & Pal. Q., p. 72.
2.—Journ. of Geology (1916) xxiv., p. 751.
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6.—Geol. & Pal. Q., p. 70.
7.—G.R.N.D. (1870).
8.—Geol. & Pal. of Q., p. 95.
9.—G.R.N.D. (1870), p. 6.
10.—P.R.S. Vic. (1905) xxiii., pt. i., p. 9.
11.—Letter dated 6/3/29.
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15.—Memo. dated 24/6/29.
16.—Q.G.S. Pub. (1879) No. 1, p. 13.
17.—Geol. & Pal. Q., p. 138.
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19.—Q.G.M.J. (1921) xxii., p. 405.
20.—Q.G.M.J. (1928) xxix., p. 389.
21.—Q.G.S. Pub. (1902), No. 172.
21A.—B. Dunstan, Geol. Sur. MS. Map.
22.—Geol. & Pal. Q., p. 140.
23.—Geol. & Pal. Q., p. 116.
24.—Geol. & Pal. Q., p. 113.
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26.—Q.G.S. Pub. (1923) No. 274, p. 8.
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32.—Q.G.M.J. (1924) xxv., p. 78.
33.—Rec. N.S.W. G.S. (1896), vol. v., pt. i., p. 39.
34.—Geol. & Pal. Q., p. 133.
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36.—G.R.N.D. (1870), p. 6.
37.—Geog. of Q. (1916), p. 171.
38.—P.R.S. Q. (1927) xxxix., p. x.
39.—Q.G.M.J. (1928) xxix., p. 386.
40.—Q.G.M.J. (1929) xxx., p. 157.
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42.—Q.G.M.J. (1923) xxiv., p. 457.
43.—A.A.A.S. (Hobart 1928), p. 76.
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45.—Ibid.
46.—P.R.S. N.S.W. (1921) lv., p. 125.
47.—A.R.M.D. (N.S.W. 1911), p. 192.
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56.—Mem. N.S.W. G.S. (1887), vol. 1 (Geol.), p. 53.
57.—Bull. G.S.A. (1928), vol. 39, No. 3, pp. 785 and 873.
58.—Q.G.M.J. (1928) xxix., p. 441.
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68.—Q.G.M.J. (1924) xxv., p. 46.
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81.—P.R.S. Q. (1924) xxxvi., pp. 45 and 64.
82.—P.L.S. N.S.W. (1929) liv., pt. 1, Plate A.
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89.—A.A.A.S. (Hobart 1928), p. 77.
90.—Q.G.M.J. (1928) xxix., p. 384.
91.—Q.G.S. Pub. Nos. 131 and 149.
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93.—Geol. & Pal. Q., p. 72 et seq.
94.—Geog. of Q. (1916), p. 172.
95.—Q.J.G.S. Lond. (1872) xxviii., pt. 3, p. 317.
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98.—Q.G.S. Pub. (1904) No. 194.
99.—Q.G.S. Pub. (1898) No. 120 and Map.
100.—Ibid., p. 8.
101.—Q.G.S. Pub. (1918), No. 264, p. 11.
102.—M.R. No. 12, N.S.W. (1908), p. 10.
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106.—Q.G.M.J. (1923) xxiv., p. 457.
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110.—Ibid., p. 471.
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115.—Q.G.M.J. (1925) xxvi., p. 474.
116.—A.A.A.S. (Perth 1926), p. 281.
117.—Ibid. et Q.G.M.J. (1928) xxix., p. 286.
118. Q.G.M.J. (1925), xxvi., pp. 469-470.
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139.—P.R.S. Q. (1925) xxxvii., p. 20.

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152.—Q.G.S. Pub. (1923) No. 274, p. 8.
153.—Q.G.M.J. (1927) xxviii., pp. 185-189.
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165.—Rec. N.S.W. G.S. (1896), vol. v., pt. 1, p. 26, pl. 3 and 4.
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167.—M.R. No. 14 N.S.W. (1911), p. 68.
168.—(See 166.)
169.—A.R.M.D. (N.S.W. 1925), p. 127.
170.—A.R.M.D. (N.S.W. 1925), pp. 116 and 130.
171.—Letter dated 4/6/29.
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178.—P.R.S. N.S.W. (1911) xlv., pp. 159-168.
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182.—Q.G.S. Pub. (1879), No. 4.
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184.—Ibid., p. 863.
185.—Ibid., p. 782 (see also p. 848).
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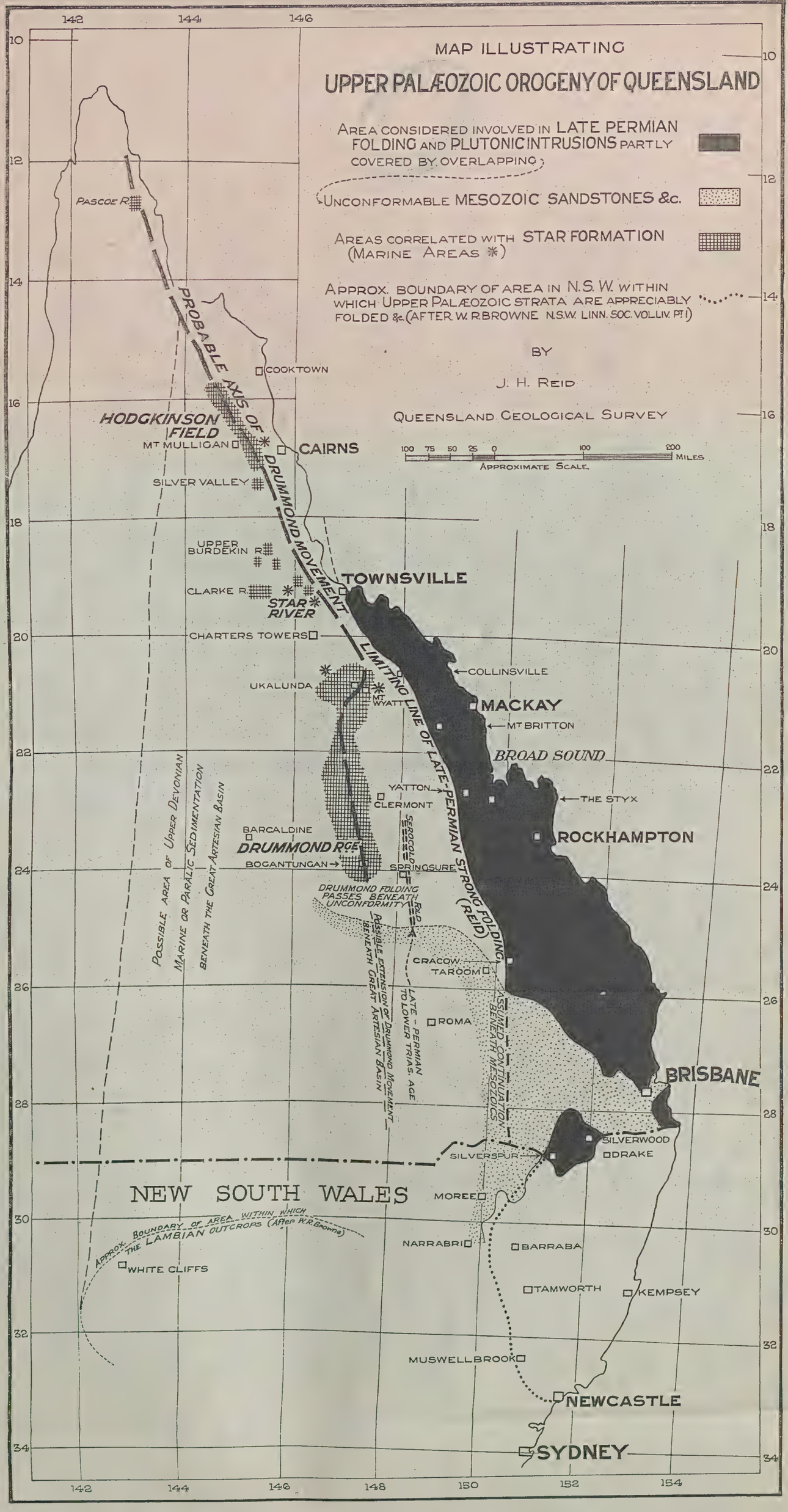
MAP ILLUSTRATING
UPPER PALÆOZOIC OROGENY OF QUEENSLAND
AREA CONSIDERED INVOLVED IN LATE PERMIAN FOLDING AND PLUTONIC INTRUSIONS PARTLY COVERED BY OVERLAPPING
UNCONFORMABLE MESOZOIC SANDSTONES &c.
AREAS CORRELATED WITH STAR FORMATION (MARINE AREAS *)
APPROX. BOUNDARY OF AREA IN N.S.W. WITHIN WHICH UPPER PALÆOZOIC STRATA ARE APPRECIABLY FOLDED &c. (AFTER W. R. BROWNE N.S.W. LINN. SOC. VOL LIV. PT I)
BY
J. H. REID
QUEENSLAND GEOLOGICAL SURVEY
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NEWCASTLE
SYDNEY

CONTACT US

QUEENSLAND
DEPARTMENT OF MINES

GEOLOGICAL SURVEY OF QUEENSLAND
(A. K. Denmead, M.Sc., Chief Government Geologist)

PUBLICATION No. 278A

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TO

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By J. CLEARY

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(277) Geological Reconnaissance between Roma, Springsure, Tambo and Taroom (The Carnarvon Ranges and Buckland Tableland) by H. I. Jensen, D.Sc., assisted by J. R. T. Dunlop. 8vo. 1926.

(278) The Queensland Upper Palaeozoic Succession by J. H. Reid, A.S.T.C. 8vo. 1930.

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